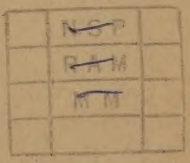
COMMITTEE OF THE PRIVY COUNCIL FOR
AGRICULTURAL RESEARCH

REPORT OF THE AGRICULTURAL RESEARCH COUNCIL

FOR THE YEAR 1961-62

Presented to Parliament by the Minister for Science
by Command of Her Majesty
July 1963



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THE AGRICULTURAL RESEARCH COUNCIL

at Date of Report

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Assessors to the Council

Professor H. G. Lamont, O.B.E., D.Sc., M.R.C.V.S.
Professor W. T. J. Morgan, C.B.E., D.Sc., Ph.D., F.R.I.C., F.R.S.

Secretary of the Council

E. G. Cox, Esq., T.D., D.Sc., F.Inst.P., F.R.I.C., F.R.S.

Deputy Secretary:

W. G. Alexander, C.B.E., M.A.

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Scientific Advisers to the Secretary:

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R. Scarisbrick, M.A., Ph.D., M.R.C.V.S., A.R.I.C.
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F. H. Moult, M.Sc.
D. Rudd Jones, M.A., Ph.D.

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THE REPORT OF THE COMMITTEE OF PRIVY COUNCIL FOR AGRICULTURAL RESEARCH FOR THE YEAR 1961-62

TO THE QUEEN'S MOST EXCELLENT MAJESTY,

MAY IT PLEASE YOUR MAJESTY,

The Lords of the Committee for Agricultural Research of Your Majesty's Privy Council humbly submit to Your Majesty this record of their proceedings during the year from 1st April, 1961, to 31st March, 1962.

2. During the financial year 1961–62, Parliament provided a total of £6,076,000 as a grant-in-aid of the Agricultural Research Fund, the original grant-in-aid of £6,044,000 having been increased by a supplementary estimate to provide for the cost of certain pay awards. The total was based on estimated current expenditure of £5,682,500 gross, receipts of £387,100 and capital expenditure of £780,600 on buildings and special equipment.

3. We have received from the Agricultural Research Council their report, which we now submit, for the year ended 31st March, 1962. In accordance with the pattern adopted last year, it contains accounts of the research in progress at those institutes which received Visiting Groups during the year, namely the Grassland Research Institute, the National Institute of Agricultural Engineering, the National Vegetable Research Station and the Scottish Horticultural Research Institute. In addition a summary is included of the work of two of the Council's research Units, namely, the Unit of Experimental Agronomy and the Unit of Insect Physiology.

4. The report describes the steps which have been taken to keep under continuous review research on the effects of toxic chemicals used in agriculture and food storage. We are pleased to record the establishment of the inter-departmental Research Committee on Toxic Chemicals under the chairmanship of Professor A. C. Frazer, which has already examined in detail the recommendations of Sir Harold Sanders' Research Study Group on Toxic Chemicals and the allocation of responsibility between the Agricultural Research Council and the other Research Councils.

5. During the year the Council received authority to set up a Meat Research Institute to which research on meat, at present undertaken at the Low Temperature Research Station at Cambridge, will be transferred and new work, on the growth and properties of meat tissues and factors influencing quality, will be undertaken. Agreement has been reached with the University of Bristol to establish the Institute on a site adjacent to the University Veterinary School. Other research at present undertaken at Cambridge will be transferred to a new Food Research Institute, and the Governing Body of the new University of East Anglia has agreed to make a site available to the Council near that University. Part of the work at present being carried on at the Council's Ditton Laboratory will ultimately be transferred to the new Food Research Institute.

6. Early in 1962, the SAT type of foot-and-mouth virus appeared outside Africa for the first time and, spreading rapidly through the countries of the Near East, reached European Turkey by September. The European Commission for the control of foot-and-mouth disease recommended the organisation, under F.A.O. supervision, of the vaccination of cattle, sheep and pigs in the border zones between European Turkey, Greece and Bulgaria. The inactivated vaccine required is being provided by the Foot-and-Mouth Disease Research Institute. Your Majesty's Committee is pleased to record this and other activities of the Council which are outlined in the report on the assistance which has been given to territories overseas.

7. Accounts are given of the ways in which new plant material of potential interest to breeders is collected and developed, of a new method for the rapid analysis of milk, and of advances in the investigation of scrapie disease of sheep.

8. The Council has considered the recommendations contained in the report of the Committee on the Management and Control of Research and Development and has paid particular attention to that concerning the siting of research establishments.

9. Evidence was submitted on behalf of the Council to the Committee on Higher Education ; this evidence referred particularly to the Council's interest, discussed in the report, in the training of potential recruits to the Scientific Officer class of the agricultural research service.

10. During the year under report we appointed one new member to the Agricultural Research Council: William Thomas Williams, D.Sc., Ph.D., A.R.C.S., D.I.C., Professor of Botany in the University of Southampton, on the retirement, after ten years' service, of Professor S. J. Watson, C.B.E., D.Sc., F.R.I.C., F.R.S.E. We also appointed, for a second term of five years, Ronald Everett Glover, M.A., D.Sc., F.R.C.V.S., Principal and Dean of the Royal Veterinary College.

11. Your Majesty has been graciously pleased to confer the honour of Knight Bachelor on David Lowe, C.B.E., F.R.S.E., and Harold George Sanders, M.A., Ph.D., and Commander of the Most Excellent Order of the British Empire on Alastair Campbell Frazer, B.S., M.D., D.Sc., Ph.D., F.R.C.P., members of the Agricultural Research Council.

12. His Grace the Duke of Northumberland, Chairman of the Council, was elected President of the Royal Agricultural Society of England for 1962.

13. Professor Sir Hans A. Krebs, M.A., M.D., D.Sc., F.R.C.P., F.R.S., a member of the Council, was awarded the Copley Medal of the Royal Society for his distinguished contributions to biochemistry.

14. Sir John Ritchie, C.B., B.Sc., D.V.Sc., LL.D., F.R.C.V.S., D.V.S.M., F.R.S.E., a member of the Council, received the Bledisloe Veterinary Award and Medal for outstanding achievements in the veterinary field.

15. Hitherto, the Council has had only one Assessor, namely an official of the Ministry of Agriculture, Northern Ireland, appointed to maintain a link with that Ministry. Professor H. G. Lamont, O.B.E., D.Sc., M.R.C.V.S., has served in this capacity for a number of years. In order to establish a

closer formal liaison with the Royal Society, the Council, in March, 1962, invited the Royal Society to nominate a biological Vice-President as an Assessor to attend its meetings. Professor W. T. J. Morgan, C.B.E., D.Sc., Ph.D., F.R.I.C., F.R.S., has been nominated to assist the Council in this way.

On behalf of the Lords of the Committee for Agricultural Research of Your Majesty's Privy Council.

HAILSHAM,
Minister for Science.

E. G. COX,
Secretary to the Committee of Privy Council for Agricultural Research.

1*st July*, 1963.

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THE REPORT OF THE AGRICULTURAL RESEARCH COUNCIL FOR THE YEAR 1961-62

To the Lords of the Committee of Privy Council for Agricultural Research

The Agricultural Research Council begs leave to submit the following Report upon its proceedings during the period from 1st April, 1961, to 31st March, 1962.

The Research Council system in this country is based essentially on two simple propositions: that scientific research is the search for new knowledge about the natural world, which ought to be sought and disseminated freely, irrespective of its economic or political significance, and that it is a highly specialised activity, requiring aptitudes and skills possessed only by a small minority, which cannot effectively be directed by laymen. The community may be quite clear about the broad general objectives towards which research ought to be directed, but it has been thought right to leave the decisions about the methods of attaining the objectives to Research Councils composed largely of scientists, on whom is laid the dual responsibility of safeguarding the integrity of the scientific investigations under their control and of ensuring that the needs of the community are faithfully served.

Not long ago it would have been generally agreed that the broad general objective of agricultural research was the increase of the technical efficiency of agriculture in every way possible, and in this country, *pace* the wool producers and the Somerset teasel growers, this is virtually synonymous with the increase in technical efficiency of food production. But it is no longer possible in this densely populated and predominantly urban country for a highly efficient food-producing industry to operate without regard to the effects of its operations on the rest of the community; thus in recent years it has been increasingly realised that the objective of research must be not only to increase efficiency but to enable it to be done in such a way that other legitimate interests do not suffer. The arrangements, referred to elsewhere in this report, to keep under review and to intensify research on toxic chemicals used in agriculture provide an obvious example of the way in which those responsible for research take account of such changes of emphasis. Again, the Council's intention to encourage research relating to quality of food indicates a similar awareness of the need to define efficiency of production in a less narrow way than in the past. Undoubtedly time will bring other modifications to the broad general objectives of agricultural research; it may be, for example, that because of the need for greater productivity, as distinct from greater total production, more weight will be given to operational research in agriculture. Possibly also it may be thought good to put more emphasis on research that may benefit not only British agriculture but food production in under-developed countries as well.

The esoteric nature of research presents a difficulty that is particularly marked in the case of agriculture, and a detached observer of the farming scene might be tempted to say, paraphrasing Macaulay's remark about the Navy of Charles II, that, although many farmers and many scientists are deeply

concerned with the advancement of agriculture, the farmers are not scientists and the scientists are not farmers. This, with rare exceptions, is true, and no good can come of any attempt to pretend otherwise ; nevertheless the implication of a gulf between farmers and scientists is misleading and becomes more misleading every year. An increasingly well-educated farming community is becoming more accustomed to applying the results of research, and agricultural scientists are increasingly being tempted to come out of their laboratories both to see agricultural problems at first hand and to explain to non-scientists what it is they are about. For example, the scientific principles underlying the methods whereby scientists distinguish between European and African strains of foot-and-mouth virus, or infuse more capacity for winter growth into a grass, are bound to be obscure to those who have not had some training in virology or genetics respectively. But many farmers did see, with understanding, the joint demonstration of developments in grass-breeding that three research institutes provided at the last Dairy Show, and we believe that technicalities will not deter many farmers from reading and profiting by the accounts of these and various other developments given in this report.

COMMITTEE ON THE MANAGEMENT AND CONTROL OF RESEARCH AND DEVELOPMENT

The report of this Committee, which was set up by the Lord President in 1958 to enquire into the techniques employed by Government Departments and other bodies wholly financed by the Exchequer for the management and control of research and development carried out by them or on their behalf, was published in December, 1961. The Council has carefully considered the recommendations contained in the report which are relevant to its activities. In the civil field, the recommendations can be regarded as setting standards of good practice to be followed as closely as the circumstances of particular organisations and laboratories permit.

A matter to which the Committee drew attention, as did the Barlow Committee in 1943, was the need to site research establishments within easy reach of a university or close to other establishments working on kindred problems. It also commented that some of the research stations for which the Council is responsible seemed to be both too small and too isolated and recommended that the possibility of amalgamating or grouping them should be examined.

The Council has always had in mind, as a major factor in deciding on a site for a new enterprise, the importance of proximity to a university and of developing close academic relations. With this in view, the Council has decided to establish the new Meat Research Institute near the Veterinary School of the University of Bristol and the Food Research Institute is to be set up at Norwich in close association with the University of East Anglia. It is proposed in due course to transfer to the Food Research Institute some of the work at present undertaken by the small staff of the Ditton Laboratory. In this way two major groupings will be formed in the field of food science, each associated with an appropriate University. Consideration has also been given to the future work and location of the John Innes Institute and, as recently announced by the University of East Anglia and the John Innes Trustees, formal academic relations are to be established between the University and the Institute in anticipation of the eventual transfer of the Institute to Norwich.

The overriding consideration must be to locate research establishments where they can best do their work, and the circumstances of agricultural research differ in some respects from those of other branches of research. Farming land is often an essential feature and the availability of land of the right type and in the appropriate climatic environment may be the dominating factor in determining location. In some cases, for example to avoid introduction of infection or to minimise the dangers of its escape, it may be desirable to seek some degree of isolation in the siting of a research station.

COMMITTEE ON HIGHER EDUCATION

The Secretary, on behalf of the Council, submitted written evidence to the Committee on Higher Education and amplified this in personal discussion with the Committee.

The agricultural research institutes and units employ nearly 1,000 persons in the Scientific Officer class, who are virtually all honours graduates and mostly specialists in various branches of the main sciences with a majority of biologists. The service also employs about 700 in the Experimental Officer class, a substantial proportion of whom have received higher education and many of whom are graduates. The research service is almost certainly the greatest single employer of biological research workers in the country although the annual intake is not large in relation to the annual output from institutions of higher education. Agricultural research requires an exceptionally diverse assortment of specialists in small numbers, such as soil microbiologists, plant nematologists and poultry physiologists, who are not in great demand elsewhere, and the Council is therefore most closely concerned with postgraduate training. Nevertheless it is interested in the earlier stages of education and regards a broadly-based education, continuing through the university, as essential.

The recruits required for the Scientific Officer class are graduates of good quality who have received a firm grounding in science and mathematics on a broad basis, together with a deeper and more specialised knowledge of one particular branch of science. All, whether physical scientists or biologists, should have an adequate knowledge of physics, chemistry and mathematics. In addition a chemist, for example, needs sufficient acquaintance with biology to be able to communicate with biologists ; and botanists and zoologists need to know something of each other's subjects.

It is doubtful whether it is possible to achieve the required standards within the confines of a three-year honours course. Potential research workers should expect to undertake four or more years of formal training between leaving school and taking up a professional appointment at a research institute. This might be achieved by means of a four-year honours course in which three or more general science subjects are taken during the first two or three years and are followed by specialisation in a particular subject during the second part of the course. Alternatively, students graduating at the end of a three-year honours course in one of the natural sciences might take a postgraduate course of one or two years in a special branch (such as virology, entomology, nematology) leading possibly to a M.Sc. degree.

However well balanced the first degree course, the graduate will rarely be fully equipped to take his place at once in an agricultural research team. Above all he needs training in research methods—especially in the mode of approach to problems, which may be called the strategy of research. And even if he has taken all the appropriate subsidiary subjects there are branches of the sciences themselves which are essential for some posts in agricultural research but are not commonly taught to any depth in first degree courses. Plant pathology and virology, entomology, nematology, biometrics and branches of soil science are examples.

Training that cannot be provided by the universities must be given within the research institutes and a certain amount of "training on the job" is readily undertaken. It should not, however, be necessary to include formal instruction, which can be given more efficiently in seats of higher education. For a variety of reasons therefore the Council considers that more emphasis might with advantage be placed on post graduate courses of formal instruction.

The Council awards annually about 30 postgraduate studentships to honours graduates in science, holders of veterinary qualifications or graduates in agriculture or horticulture who have shown special interest and aptitude in one of the basic sciences. A studentship permits a graduate who wishes to make a career in research either to take a further course of study or to undertake a specific research project under supervision as a means of training in research methods. Studentships for advanced courses of study help those who wish to improve their knowledge in subjects allied to that of their first degree—for example, botanists or zoologists needing further instruction in biochemistry as a preparation for research in plant or animal physiology. Research studentships are normally extended for a period of three years, and the holders almost invariably register for higher degrees, although they are not required to do so. In appropriate cases awards can be continued for a total period of four years so that a student may receive formal training for one year followed by three years on a research project.

RESEARCH COMMITTEE ON TOXIC CHEMICALS

In December, 1959, the Minister of Agriculture, Fisheries and Food, together with the Minister for Science, the Secretary of State for Scotland and the Minister of Health, appointed a Research Study Group on Toxic Chemicals under the chairmanship of Sir Harold Sanders, the Chief Scientific Adviser on Agriculture to the Ministry of Agriculture, Fisheries and Food, to study the need for further research into the effects of the use of toxic chemicals in agriculture and food storage.

The Study Group's report, which was published in September, 1961, did not reveal any serious gaps in the research effort on toxic chemicals, but it did indicate the need for more work in some directions. The Government accepted the conclusions of the report; subsequently the Research Councils and the Ministry of Agriculture, Fisheries and Food were authorised to make some additional staff appointments whereby it has been possible to intensify certain surveys and researches and to initiate some new work.

The Study Group expressed the hope that there would be periodic consultations between the Research Councils to keep in review the research being done under the aegis of each, especially that relating to the interactions between pesticides use and wildlife. The Minister for Science asked the Agricultural Research Council to make the necessary arrangements on behalf of the four Research Councils. An inter-departmental Research Committee on Toxic Chemicals was therefore set up under the chairmanship of Professor A. C. Frazer ; its present membership is given on page 70.

The terms of reference of the Research Committee are : —

(i) To keep under review research done under the auspices of the Research Councils on the effects of toxic chemicals used in agriculture and food storage ; and to make recommendations for future research.

(ii) To report to the Agricultural Research Council and through it to the Minister for Science.

The Committee held its first meeting in March, 1962, when it reviewed the field of research, and examined in detail the recommendations made in the Sanders' Report and the allocation of responsibility between the Research Councils. The Committee concluded that, although no large expansion of research facilities was required, more attention should be given to ecological studies on wild animals and birds and on the interdependence of animals, plants, insects and other organisms. Further work was required, too, on the mode of action of pesticide chemicals and on the nature of acquired resistance to insecticides. It was felt that such studies would be of value in discovering and developing less toxic and more selective chemicals, and more efficient methods of application.

The Study Group did not concern itself with biological methods of control since these were outside its terms of reference. The Research Committee, however, considered that more attention should be given to biological control and to the integration of biological and chemical control methods and further effort in this field is being made at a number of research institutes.

PLANT COLLECTION AND INTRODUCTION

A collection of varieties of his crop and related wild species is the plant breeder's store to which he resorts for useful genes to give improved performance to his new productions. This has always been true ; and modern plant-breeding methods, while they make for more efficient use of the variation available in the store, do not lessen the importance of a continual replenishment. Indeed they enhance it, for the more highly bred our crops become, the greater is the difficulty of effecting further genetic improvement ; and the more efficiently the known variation has been exploited, the greater the need to press further afield the search for new sources.

A great deal is done nowadays by exchange of potential breeding material between plant-breeding stations in different countries, and where this method is appropriate it is evidently the most convenient and economical—costing little but the exercise of goodwill. There are still circumstances, however, in

which material has to be obtained in harder ways by exploration and collection in the field in countries where knowledge of the local flora is at best rudimentary. The successes that are achieved are also reminders of the great range of plant variation that still exists unexploited in natural vegetation and in primitive cultivations.

Grasses

A noteworthy example of useful plant introduction is the recent discovery in North Africa of pasture grasses that promise to help our plant breeders very materially in their efforts to produce varieties for grazing outside the usual season. These grasses have already had some publicity on account of their unusual behaviour ; but their usefulness to breeders, which is likely in the long run to be more significant than their immediate performance, has not been emphasised.

The facts, in brief, are that the new grasses are varieties of tall fescue (*Festuca arundinacea*), a species which occurs in other forms in Great Britain and is used to some extent as a pasture grass. They were found among a collection of grasses gathered in Algeria and Morocco under the auspices of the Food and Agriculture Organization of the United Nations. Material from the collection was received in 1956 at the Plant Breeding Institute, Cambridge, where it attracted attention by its ability to grow during the winter. In 1957 some of it was sent to the Grassland Research Institute at Hurley for observation, and the two Institutes have collaborated in subsequent developments. The Plant Breeding Institute has been specially concerned with improvement of the original stock, which was very mixed. Selection was begun at once at Cambridge, and by 1959 two synthetic varieties had been built up which have been used in the later trials while the breeders continue their efforts to effect further improvement. The Grassland Research Institute has concentrated on establishing the agronomic characters of the material. Sward trials were laid down as soon as there was enough seed, which was in 1959, and by 1961 much useful information had been accumulated.

In yield trials at Hurley the North African tall fescues have produced up to one ton per acre of dry matter between October and mid-March, which is about twice the quantity produced by Short Rotation ryegrass and three to four times as much as that produced by other perennial grasses commonly grown. Assays indicate a digestibility of a fairly high order for winter grass. On these findings it is reasonable to hope that these grasses may play an important part in extending the grazing season. It has to be noted, nevertheless, that more information is necessary before they can be put on the market for the use of farmers. Like any other crop varieties, they have defects as well as virtues—for example, although they grow more than indigenous varieties in autumn and winter, they yield much less in spring and summer. Their place in practical farming has therefore to be established by further trials, and two or three more years of experimental work may be necessary to do this. Meanwhile, because of the considerable promise that these grasses show, they have been put into a wider range of trials than is usual for new varieties at an early stage of development ; and unusual steps have been taken to multiply seed supplies in advance of the trial results. By the end of 1965, there should be enough seed for all if the trial results justify its use.

Further breeding work is in hand both at Cambridge and at the Welsh Plant Breeding Station, Aberystwyth. To the breeders, the exciting feature of these grasses is that they have a different pattern of growth from the indigenous varieties and provide a new source of useful variation. They may therefore afford a starting point for a series of new varieties with different growth rhythms, combining the best characteristics of both British and introduced stocks.

Though so far the most interesting, these are not the only grass introductions that have been made recently. There has been much activity in the introduction and study of grasses from the Mediterranean region and elsewhere which may be useful for building up the specialised varieties needed for various purposes in Britain. Members of the Welsh Plant Breeding Station collected in Portugal in 1961 ; and at the end of the period covered by this report a joint expedition manned from the Plant Breeding Institute, the School of Agriculture at Cambridge, the Welsh Plant Breeding Station and the Grassland Research Institute was collecting in Morocco and Tunisia.

Potatoes

The Commonwealth Potato Collection maintained at the John Innes Institute, Bayfordbury, is one of the best of its kind in the world and is continually being augmented in various ways from the great reservoir of natural variation that exists in the mountain regions of South and Central America. The foundation of this Collection was laid in 1939 by the Commonwealth Agricultural Bureaux organisation, which sent a collecting expedition to Central and South America and introduced more than 1.000 specimens for study in special greenhouses provided at Cambridge by the Nuffield Foundation. In the next ten years the material was classified and tested for resistance to various diseases and pests, and samples likely to be useful in potato breeding were distributed to all interested Commonwealth countries and to some breeders outside the Commonwealth. Among many valuable results of this phase of the work was the discovery of resistance to potato root eelworm.

When the first object of providing Commonwealth plant breeders with material had been largely achieved, the Collection still held very great value for fundamental genetical research on the potato. To enable that value to be exploited more intensively, the Agricultural Research Council, at the invitation of the Commonwealth Agricultural Bureaux, took over responsibility for the Collection in 1951, transferring it from Cambridge to Bayfordbury in 1955. It has received accessions from various sources from time to time. Most recently, an expedition from the John Innes Institute made a fresh collection in the Andes in 1960, driving south from Venezuela to the north of Argentina. This trip added more than 600 new items. In 1961 the Collection held more than 3,000 stocks, received 55, and sent out 40.

The figures show the size of the Collection as a repository and exchange centre for breeders' material ; but these functions, though important, are inseparable from its everyday use for cytogenetical studies of the potato, producing knowledge required for further advances in potato breeding. Size is only significant in relation to the range of variation represented. The practical value of the store depends upon the intimate knowledge of its contents obtained by continuous research by its custodians.

INFRA-RED MILK ANALYSER

Workers at the National Institute for Research in Dairying have devised a new method for the rapid analysis of milk based upon the absorption of infra-red radiation. This method has been patented by the National Research Development Corporation and tests are now being made on a prototype instrument which will determine fat, protein, lactose and solids-not-fat in 25 ml of milk in less than one minute.

The milk sample is first homogenised at low pressure to break up the larger fat globules which would otherwise introduce errors ; this process is started automatically when the sample is poured in. The milk is then transferred automatically into one of a pair of cells placed in the infra-red radiation beams. A comparison cell containing water is used to balance out the water absorption bands. Push-button selection of the appropriate wavelengths for the monochromator enables the intensities of the absorption bands of the main components to be measured in turn. These intensities are automatically converted into optical densities and fed into a digital voltmeter which gives direct readings of the milk composition.

THE USE OF MICE IN SCRAPIE RESEARCH

It has been known for some time that scrapie disease of sheep can be reproduced experimentally by inoculating material from the brains of affected sheep into the brains of normal sheep. Sometimes only half the recipients would develop the condition and this only after an incubation period of as much as two years. Investigation of the disease was therefore a tedious and expensive business. The first alleviation of the situation occurred when it was found that the disease could be transferred from sheep to goats and that when this had been done almost every goat subsequently inoculated developed the disease. This meant that experiments with goats needed fewer animals than corresponding experiments with sheep. More recently, it has been found at Compton that certain strains of mice inoculated with material from the brains of certain infected goats developed a nervous disease and that this could similarly be transmitted from mouse to mouse and back to goats. There are good reasons for thinking that the disease produced in mice is experimental scrapie and if this proves so a great step forward will have been taken for, by using mice, many problems in the investigation of the disease could be solved with greater speed and certainty and with much less expense. Many different laboratories throughout the world have undertaken confirmatory experiments. Confirmations of the findings at Compton are now coming in, including reports of work both at Compton and Moredun which, in its preliminary stages, indicates that the disease of the nervous system has been induced in mice by direct transfer from scrapie-affected sheep.

VETERINARY THERAPEUTIC TESTING BOARD

Following representations by the British Veterinary Association to the Lord President regarding the need for facilities for the impartial testing of therapeutic substances for veterinary use, and discussions with the B.V.A. and with the Association of British Pharmaceutical Industry about the organisation of a testing scheme, the Council set up in 1957 a Veterinary Therapeutic Testing Board, and approved the general lines of a Testing Scheme to be

operated by the Board. This Scheme provided for tests to be carried out, if the Board so decided, on application by a manufacturer or importer of the substance concerned ; by a veterinary professional organisation ; by a committee of the Council ; or on the Board's own initiative.

In fact the number of proposals received was very small, and practical difficulties prevented a satisfactory trial being conducted in the few cases which the Board felt justified in entertaining.

The Council accordingly decided to disolve the Board and this has been done. It was recognised that there may still be a need in some circumstances for field trials of substances that have been proved under laboratory conditions and the Council has agreed that it would be prepared, as the need arises, to consider organising such trials on an *ad hoc* basis.

FOOT-AND-MOUTH DISEASE VACCINE

In the last report of the Council, mention was made of the agreement concluded between the Foot-and-Mouth Disease Research Institute, Pirbright, and the Wellcome Foundation for the production on a commercial scale of live vaccines against different types of foot-and-mouth disease, in particular, those found in Africa.

Before the Wellcome Foundation had been able to establish an organisation at Pirbright, the Institute was called upon for assistance by the Governments of South Africa and South West Africa. At the end of July, 1961, foot-and-mouth disease (type SAT 1) broke out in the cattle farming districts of South West Africa ; this area had not previously suffered from the disease and the animal population was therefore highly susceptible. A rapid spread of the disease created a serious situation and the veterinary authorities appealed to Pirbright for assistance in September. During the next five months the Institute was able to make and send out by air, in casks specially designed for this purpose, approximately 2½ million doses of vaccine, of which about one quarter was live vaccine and the remainder inactivated. The use of these vaccines, reinforcing other measures taken on the spot, served to limit the spread of the disease. Moreover, the Institute gained very valuable experience in the continuous production and despatch of large batches of vaccine as well as obtaining useful information about its effects in the field.

Early in 1962, the SAT type of virus appeared outside Africa for the first time and spread rapidly through countries in the Near East. Steps to prevent the westward spread of the disease were unsuccessful and by September, 1962, it had reached European Turkey. This presented a very serious threat to the rest of Europe, since previous infection or vaccination against any of the strains of foot-and-mouth disease normally found in Europe would offer no resistance to this new invader. The European Commission for the control of foot-and-mouth disease has recommended the organisation, under F.A.O. supervision, of vaccination with inactivated vaccines of cattle, sheep and pigs in the border zones between European Turkey, Greece and Bulgaria. The inactivated vaccine required for this operation is being provided by the Institute. Live vaccine, up to the time of writing this report, has not been used in Europe, but if it were required, it would be manufactured by the Wellcome Foundation under the agreement with the Institute.

The new building for the production of live vaccine has now been completed. Some modification of the lay-out of the building was made possible by the discovery at the Institute of an improved method of production of attenuated vaccines using tissue culture instead of baby mice.

FOOD RESEARCH

During the year under review the Council has continued to plan the future organisation of food research. Some change in existing arrangements was inevitable owing to the need to find alternative accommodation for the research being carried on at the Low Temperature Research Station when its premises in Cambridge have to be vacated and returned to the University in 1966. The opportunity is being taken to re-group into two main divisions the research on food at present undertaken at the Council's institutes.

The Council has received authority to set up a Meat Research Institute to which the current research on meat at the Low Temperature Research Station will be transferred. In addition new work, and especially new basic studies of the growth and properties of meat tissues and factors influencing quality, will be undertaken. It is intended that the Institute will be concerned particularly with problems of meat from cattle, sheep and pigs. Approximately half the capital and running costs of the Institute are to be provided by a levy on the meat industry. Agreement has been reached with the University of Bristol to establish the Institute on a site adjacent to the University Veterinary School at Langford (near Bristol) and plans for the new building are being prepared. The Council has recently announced the appointment of Dr. M. Ingram, formerly Deputy Director of the Low Temperature Research Station, as Director of the Meat Research Institute.

The Council also plans to set up a Food Research Institute to continue and extend the research on food (other than meat) that has been in progress at the Low Temperature Research Station. Part of the work at present being carried on at the Council's Ditton Laboratory will ultimately be transferred to the new Food Research Institute. In consultation with the Ministry of Agriculture, Fisheries and Food, arrangements will also be made for the continuance of advisory work on fruit storage which has in recent years been undertaken at Ditton.

The Governing Body of the new University of East Anglia has agreed to make a site available to the Council for the establishment of the Food Research Institute in proximity to the University. Planning of this new Institute is proceeding.

FARM BUILDINGS RESEARCH

The three principal aspects of the work of the Council's Farm Buildings Unit have continued to be the survey of farm buildings in Great Britain, the compilation of the bibliography of farm buildings research and the operation of the Experimental Farm Buildings Scheme. The field work of the survey has now been completed and the findings, which are currently being analysed, will provide a comprehensive picture of the scale and kind of farm buildings in use at the time of the survey. The bibliography, which lists publications on farm buildings research in countries where conditions are relevant to those in

Great Britain, has been published in parts relating to buildings for pigs, potato storage, poultry, cattle, grain drying and storage, fodder storage, and for miscellaneous purposes. Initially each part related to publications appearing between the 1st January, 1945 and 30th April, 1958 ; supplements already published or in preparation extend the period of review to the 31st December, 1961.

The Council's programme of experimental projects under the Experimental Farm Buildings Scheme is based on the principal problems in farm buildings as disclosed in the applications for grant. By the end of June, 1962, that is after two years' operation, the Council had received 248 applications for grant of which 57 had been approved, 23 had been withdrawn, 134 had been rejected and 34 remained under consideration. The experimental projects have been formulated by the Council's Farm Buildings Unit with the co-operation of other research organisations and with the technical staffs of the Agricultural Departments. During the first year of the scheme these projects related to methods of economising straw and labour in cattle yards ; comparison of poultry houses with wire-mesh or slatted floors with deep litter houses ; methods of housing hill sheep ; the bulk storage of fertilisers on the farm ; structures and ancillary equipment used for the handling and feeding of bulk cattle foods ; and pig housing. These continued during the second year and additional projects included studies of potato chitting houses, of buildings for potato storage, and of glasshouse design. Approximately £23,500 was paid in first instalments of grant in the financial year 1961–62 in respect of work costing nearly £80,000 ; about nine-tenths of the money paid was attributable to expenditure on experimental features and the remainder to expenditure on associated non-experimental building work.

VISITING GROUPS

In accordance with the practice introduced last year, brief reports of the research in progress at those institutes which received Visiting Groups during the year are given below.

The Council's system of Visiting Groups, which was described in some detail in its report for 1960–61, is one of the principal means by which the Council exercises general oversight and control of the research programmes of the institutes. The Committee on the Management and Control of Research and Development was particularly attracted by this system as a means of obtaining an independent check on the work of research establishments and recommended that consideration should be given to the extension of its use to other organisations in the field of civil research.

During the year 1961–62 Visiting Groups were received by the following institutes :—

Institute of Animal Physiology
National Institute of Agricultural Engineering
Grassland Research Institute
National Vegetable Research Station
Scottish Horticultural Research Institute

INSTITUTE OF ANIMAL PHYSIOLOGY

At the end of the war, when the Council reviewed the development of agricultural research, it formed the view that a lack of knowledge of the fundamental physiology of farm animals was impeding progress towards the improvement of animal health and production. The Council accordingly established an Institute of Animal Physiology at Babraham near Cambridge and appointed Dr. I. De Burgh Daly, F.R.S. as its first Director.

Dr. Daly was himself a physiologist and, deciding that physiology should be strengthened and extended by the addition of biochemistry and experimental pathology, soon attracted Sir Rudolph Peters and Sir Alan Drury to head departments in these subjects. For the next ten years the Institute grew along these three lines, building up staff and laboratories, and at the same time gradually acquiring an international reputation for the quality of its scientific work. In 1958 Dr. Daly retired and was soon followed by his two distinguished aides ; Dr. J. H. Gaddum, F.R.S., succeeded Dr. Daly as Director and quickly gathered a new team of senior workers round him. The scientific staff of the Institute now numbers about 40. A report of the Institute's activities has recently been published and can be obtained from the Secretary of the Institute.

Department of Physiology

A wide variety of subjects is being investigated by the members of the Physiology Department under Dr. R. D. Keynes, F.R.S. One interesting line of work that is now being developed is a climatic study of pigs and for this special facilities have recently been built. The environment in which pigs are kept influences their growth, and it is desirable to know as fully as possible the action of the different components of the environment. The conditions for optimum growth can then be defined for different ages and types of pig and for different management regimes, and housing for pigs can be designed accordingly. The laboratory constructed for this work is of very flexible design ; it is possible to construct within it rooms of various sizes in which temperature, humidity, rate of change of air flow, and other factors can be varied over wide ranges. Pigs can be kept in these controlled environments for long periods, if need be, and their reactions studied in detail. When a particular series of investigations has been completed the room in which they were made can be dismantled and a new set of conditions established.

Various other projects are being undertaken in association with this work. It is important to be able to measure certain aspects of the body composition of pigs—and other meat producing animals—such as the amount of body water and of lean body mass. These measurements are being studied in collaboration with workers outside the institute. Methods of measuring blood flow, including the output of the heart, in these animals are being devised so that the adjustments to its circulation that the animal makes in different environments can be studied and the loss of heat from various parts investigated. The important process of acclimatisation to different environments is also being studied, and this includes an investigation of the pig's ability to sweat.

Lactation is, of course, a process of the greatest importance in farm animals and its study is a part of the department's activities. For a proper understanding of the process it is necessary to know what substances, brought to

the udder in the blood, are used for the synthesis of milk and in what amounts. During the investigation of this problem new and unexpected factors with a bearing on udder growth and function have been uncovered at the institute and are being studied.

Reproduction is similarly a matter of basic importance, and its study has formed part of the department's programme for some time ; at present gestation in pigs is being investigated. A very high incident (30 per cent—40 per cent) of embryonic loss occurs in the pig, and this has been studied in relation to the stage of gestation, the age of the sow, the number of litters previously born and hereditary factors. Nearly all eggs shed by the ovaries are fertilised in the sow but between the 6th and 9th day after mating about one-fifth of them have degenerated. In a very few animals nearly all embryos may die subsequently.

The food eaten by ruminant animals is digested in a manner so different from that which occurs in other animals, and the consequences of this are so far reaching, that the whole process merits, and has for some time received, the closest study. Each department of the institute has an interest in some aspect of ruminant digestion, that of the physiology department is the investigation of the secretory, mechanical and absorptive behaviour of the alimentary canal of the ruminant. Another and possibly related peculiarity of ruminants is their susceptibility to various metabolic diseases, for example pregnancy toxaemia, acetonaemia, milk fever and hypomagnesaemia. The department is investigating the factors controlling the absorption and metabolism of magnesium in the hope that further knowledge might lead to improved methods of preventing hypomagnesaemia.

In order that progress can be made on topics such as those already mentioned, the practical bearing of which is immediately obvious, it is necessary to continue at the same time a large volume of more fundamental work reaching more deeply towards the roots of the problems. Such work in the department includes studies of the membrane of the cell and the investigations of several aspects of nervous and muscular activity.

A subdepartment within the physiology department specialises on chemical physiology mainly in relation to the nervous system. Many nerves, both in the brain and other parts of the body, are known to produce their effects by releasing acetylcholine. The work of this subdepartment has centred round the formation, release and destruction of this substance which has very powerful actions and plays such a fundamental part in the control of the body.

Department of Biochemistry

The Biochemistry Department under Dr. G. D. Greville also undertakes a number of fundamental investigations, and its work in this context includes the study of several important components of living cells, in particular enzymes and phospholipids. A study of the chemical composition and structure of nerve endings aims at gaining a better understanding of the processes of nervous transmission in the hope that this, in turn, will contribute to our knowledge of the nervous disorders to which both man and animals are subject.

The rumen and the ruminant animal are the subjects of a number of investigations. It is important to know the extent to which the individual components of the diet are broken down in the ruminant stomach, and the particular component at present being studied from this point of view is protein. In the course of this investigation the importance of a hitherto unsuspected nitrogenous compound, methylamine, is being assessed. The breakdown of food material is brought about by the activities of bacteria and protozoa, both of which are present in large numbers and great variety. The role of protozoa is being considered at Babraham and attention is centred at present on one species, *Entodinium caudatum*—one of the group of oligotrich protozoa. This organism has been isolated and grown outside the rumen, a matter of great difficulty but essential before the metabolism of the organism can be studied and its contribution to the overall process of digestion assessed.

The breakdown of foods by these micro-organisms alters dramatically the nature of the food that becomes available to, and absorbed by, the ruminant. Surprisingly large amounts of acetic, propionic and butyric acids are produced in the rumen and information is being built up on the utilisation of the first and quantitatively the most important, of these acids by the sheep.

Department of Experimental Pathology

One of the principal activities of the Department, which is under Dr. T. Gillman, is the investigation of the structure, composition and reactivity of arteries. In productive farm animals, pregnancy and parturition follow one another with some regularity during their reproductive life, and while this is going on the arteries that supply blood to the uterus have to cope with large and often sudden variations in the requirement of that organ for blood. Any inability on their part to do so could well have a serious effect on the fertility of the animal. The reactions of the uterine arteries of the sow in particular have been analysed and it has been established that marked thickening of the arteries occurs in sows that have had several pregnancies ; further work is needed to establish the significance of this phenomenon. At the same time a study is being made of the composition of the uterus as it undergoes change, and particular attention is being given in both investigations to the study of connective tissue.

Most farm animals, unlike man, are born without any natural immunity to disease, and they acquire their first protective antibodies from colostrum. The survival of new-born animals under most conditions of farm management depends upon their receiving colostrum containing the necessary antibodies and absorbing them ; since antibodies are proteins and proteins are not normally absorbed undigested from the intestine in any appreciable quantity, the newly-born farm animal must have some special arrangement. The nature of this in the calf and in other animals is being studied.

Much is known about the nature, distribution, inheritance and importance of blood groups in man. Less is known about these things in farm animals, and, although knowledge of blood groups in cattle, in pigs and in poultry has been advancing steadily, sheep have not hitherto received the same attention. The Institute's flock of Clun Forest sheep is being investigated for this point of view. It is interesting that haemolytic disease does not occur naturally in

sheep and preliminary experiments at Babraham have indicated that, even when all the serological conditions for producing haemolytic disease were apparently present, lambs did not develop it.

The department is also interested in the importance of electric potentials at cell surfaces and has shown that each mammalian spermatozoon carries a negative charge which may be situated on its head or its tail and influences the way it responds to an electric field. Studies such as these may suggest possible ways of separating male producing and female producing spermatozoa.

The changes that occur in the livers of normal cattle before and after parturition have been studied for many years at the Institute, and recent investigations have shown that changes occur in the levels of fat and glycogen and in the activities of the enzymes β-glucuronidase and phosphorylase. The observations have been extended to pregnant and lactating sheep and the changes that occur in the livers of sheep made ketotic by a reduction of food intake have also been studied.

Pharmacology Unit

Pharmacological studies at the Institute are related to two main fields of interest:

(i) hormones, particularly those secreted by the adrenal cortex ;

(ii) substances involved in the functioning of the brain tissues.

Aldosterone is a hormone secreted by the adrenal cortex. It plays an essential part in maintaining the sodium balance of all body fluids and its rate of secretion is of critical importance in both healthy and diseased animals. In order to measure the secretion rate, sensitive methods for estimation of the hormone had first to be developed. During the last two years considerable progress has been made in this work as a result of improvements in operative techniques and extraction procedures ; the effectiveness of the latter has been confirmed by means of radioactive isotope techniques using tritium-labelled aldosterone.

With the aid of these new methods of estimation a study of the factors controlling aldosterone secretion is being made. It is known that increased production of aldosterone occurs during haemorhage ; work now in hand consists of determining what role is played in this by the kidneys, the pituitary, the splanchnic nerves and the chemoreceptors.

In the brain can be found many pharmacologically active substances which are distributed so unevenly that their distribution alone suggests a specific function at the sites at which they are concentrated. The amines, noradrenaline, dopamine, and 5-hydroxytryptamine, are examples of this group of substances. Their functions are being studied experimentally by observing changes in their concentrations and those of their metabolites following administration of neurologically active drugs. For example, a close correlation has been found between changes in the noradrenaline content of the brain and disturbances of cerebral function produced by drugs of the reserpine type. These studies have also shown that the response to a given treatment may vary considerably between different species of animals and that, even within a species, the constitutional make-up of the individual animal exerts a strong influence.

Other investigations in progress are concerned with the mechanism of peptide synthesis in the brain and the functions of peptidases occurring in various regions of the central nervous system.

The director also retains his strong personal interest in pharmacology and is at present working on vasodilator polypeptides.

The Group which visited the Institute in the summer of 1961 was greatly impressed by the vigorous growth of research which was apparent under the guidance of the new heads of departments. Evidence of the international reputation which this work has acquired is given by the presence at the Institute, at any time, of some 15 to 20 research students or visiting scientists who have come from many parts of the world to work for a period at the Institute.

NATIONAL INSTITUTE OF AGRICULTURAL ENGINEERING

An institute for research in agricultural engineering was set up in 1924 in the University of Oxford. During the war this became part of the National Institute of Agricultural Engineering at Askham Bryan in Yorkshire, functioning under the direction of the Agricultural Machinery Development Board of the Ministry of Agriculture and Fisheries. The Institute moved to its present site at Silsoe in Bedfordshire in 1947 and, at about the same time, a Scottish Station was established at Howden in Mid-Calder. In 1949 the Institute, together with the Scottish Station, became the administrative responsibility of the British Society for Research in Agricultural Engineering under the scientific supervision of the Agricultural Research Council. In 1962 the Scottish Station moved to the Edinburgh Centre of Rural Economy on the Bush Estate.

The Institute, which is one of the larger-grant aided institutes, is financed by the Agricultural Research Council. The Scottish Station draws its funds from the Department of Agriculture and Fisheries for Scotland. At Wrest Park there are 32 scientific and 70 experimental staff ; those employed at the Scottish Station number 6 and 8 respectively. As one would expect in a research organisation of this kind there are almost as many technical assistants and workshop staff as scientific staff at both Stations.

The function of the Institute is to undertake research applicable to the improvement of agricultural and horticultural mechanisation. This covers a much wider field of enquiry than the designing and testing of new machines, important though those items are. The practical objective may be described as helping the machinery manufacturer to help the farmer. To that end the Institute has to study and analyse mechanical operations in the field as performed by existing machines in order to formulate the engineering problems that most need attention. Useful information is also obtained from surveys of the performance of machinery on farms and the study of methods for improved utilisation. New designs are developed as far as necessary to prove the results of research, but experimental findings are published as soon as possible and made available to designers in industry for development.

The Institute assists manufacturers also by testing prototypes of new models under standard conditions, and reporting on their performance. The development of techniques for testing the many different classes of machines is, itself, a subject of research.

Recent Developments and Re-organisation.

By the time of the visit of the Group in 1961 a stage had been reached at which the Director, Mr. W. H. Cashmore, had decided that some re-organisation was desirable to provide a more rational deployment of effort on the various mechanised operations in agriculture and horticulture, to streamline the work of individual departments, and to define more precisely the limits of their programmes. The broad effect of the re-organisation has been to concentrate the work of nine operational departments into four divisions, together with Grain and Seeds, and Commonwealth Liaison Units. The main administrative responsibility has thus been divided between four divisional heads:—

Engineering Division, under Mr. H. J. Hamblin ;

Mechanisation Division, under Mr. D. I. McLaren ;

Environmental Control Division, under Mr. L. G. Morris ;

Information Division, under Mr. J. K. W. Slater.

Future of Machinery Testing.

The testing of prototype machines and production models for manufacturers has always been an important feature of the work of the N.I.A.E. but such tests are of little direct use to the farmer. Recently, the National Farmers' Unions of England and Wales and of Scotland and the agricultural machinery manufacturers have expressed concern about the facilities for testing agricultural machinery at N.I.A.E., and have suggested that the present service should be expanded into a comprehensive testing scheme to provide information, in a form that farmers can readily understand, on the comparative merits of different machines under a wide range of working conditions.

The Governing Body of the N.I.A.E. has decided, as a result of these representations, to modify and expand part of the existing N.I.A.E. testing service by providing additional information to users of farm machinery, mainly in the form of series tests. In this form of testing, a number of different makes of machines of the same broad type are tested together in one season. For the users' testing service, the series tests will be confined to production machines, and publication of reports of tests will be a condition of entry unless the model is withdrawn from production. Tests will be in two parts:—

(1) a test of a group of machines entered by manufacturers and operated under comparable conditions, together with details of working performance.

(2) a survey of machines on farms, purchased by farmers through their agents, carried out in collaboration with the Machinery Advisory Officers of the N.A.A.S. (The Chief Farm Machinery Advisory Officer, who is stationed at Wrest Park, will be able to co-ordinate this part of the scheme.)

The immediate objective of the scheme will be to undertake three or four series tests a year ; this will involve reporting on a minimum of 20 models each year.

The Governing Body of the N.I.A.E. has set up a committee to advise on the scheme ; representatives of the farming and agricultural engineering industries and of the M.A.F.F. serve on this Committee.

The Research Programme.

Detailed information about the programme is given in the annual report of the Institute. It will be apparent from the following short outline, however that, although the Institute is still very much concerned with the solution of immediate practical problems, there is an increasing amount of fundamental research going on. This is essential if the N.I.A.E. is to maintain the high reputation it has earned for developing new ideas on mechanisation in agriculture and translating them into practical machinery for use on the farm.

Engineering Division.

This Division has been largely based on the former Mechanical Engineering Department, and it will continue to follow the same general policy, which is to maintain a flexible, integrated group, capable of tackling any type of engineering problem within the field of British agriculture, but not primarily concerned with the broader aspects of mechanisation. The Division is made up of five Departments, and there is, in addition, a Consultant Mathematician. The main testing activities are concerned with tractors and tractor components.

Tractor Performance Department. During 1961 test reports were issued of 17 tractor tests including British Standard Tests, tests organised under the auspices of O.E.C.D., and tests arranged by the Institute in co-operation with the East African Machinery Testing Unit. These last tests have required the development of special methods for testing air cleaners and engine performances at high altitudes. A small one-wheel drive tractor, intended exclusively for use overseas, has been tested in East Africa.

Tractor Development Department. Over the past ten years the Department has done a great deal to assess the potential usefulness of hydrostatic transmission in tractors. Valuable work has been completed on valve and pump components, and it seems probable that the further exploitation of hydrostatic transmission will now rest with manufacturers, several of whom are already engaged on experimental work. The very valuable contribution that the N.I.A.E. has made in these studies has been generally recognised, and there is no doubt that it has provided the necessary stimulus for the industry.

Equipment Construction Department. This Department is concerned with the design and construction of special equipment which is required by other departments in the Institute and by outside research organisations. This has included in the past year a tractor test recorder, mobile weighbridges, and a windrower for the N.I.A.E. Special drills have been devised for sowing experimental plots of cereals, and harvesting equipment has been developed for harvesting small plots of cereals, herbage, peas and sugar beet.

The Department has developed an ox-drawn tool-bar which was tested recently under field conditions in East Africa. The corrosion of metal containers by fertilisers is another problem which is being tackled.

Drier Performance Department. Tests are carried out on all types of drying machinery. Reports of tests of three pyrethrum driers completed by the East African Testing Unit have been published, and the Department has been advising the Pyrethrum Board of Kenya on the effect on quality of overdrying.

The Department is responsible for investigations on the mechanisation of hop-growing. A 3-year experiment on hop picking by machine has demonstrated clearly that machine-picking is at least as satisfactory as hand-picking and perhaps a little better. Other work on hops is directed at providing the most efficient and durable wirework in hopyards.

Instrumentation Department. This Department designs and develops precision instruments for special purposes. An electronic integrator with digital output has just been completed ; this was designed for use with strain-gauge torquemeters in tests undertaken by the Mechanisation Division. An electronic tachometer has been devised for use with high-speed spray generators in studies on spraying machinery.

Equipment intended for *in situ* measurements on glasshouse soil has been developed for the Environmental Control Division. Conductivity measurements needed to determine levels of water-soluble nutrients are being made with simple electrode assemblies cast in epoxy resin. By making continuous resistance measurements with them the effect of the watering cycle on the soluble salt concentrations of the soil has been observed.

An instrument to measure osmotic pressure of the soil solution is also being developed, using soil tensiometer pots in which are supported semi-permeable membranes. It is hoped ultimately to build a control unit which will provide automatic watering in glasshouses operated by soil moisture tension. Successful control units have already been devised for mist propagation equipment.

The Department provides a general service to the Institute by calibrating instruments used in the testing departments, and checking the reliability of standards.

MECHANISATION DIVISION.

The Division is made up of three Departments and a small section dealing with metals and materials.

Cultivation Department. One of the main problems of the Department is the study of different systems of land drainage. A machine to lay drains formed from a strip of callendered p.v.c. foil has been designed and built, and development work has been completed on the design of a die to form the strip into a continuous tube underground. Measurements have been made of samples of the tube at the Institute of Land and Water Management at Wageningen in Holland and at the A.R.C. Unit of Soil Physics at Cambridge to see how its hydraulic properties compare with those of a tile drain. At Wrest Park an experiment has been laid down to compare conventional tile and mole systems with plastic drains, and more extensive field trials have been planned in collaboration with the Land Drainage Division of the M.A.F.F.

Studies on the aeration of soil were started in the Department several years ago in an attempt to determine the need for cultivations to maintain the soil in a well-aerated condition.

Considerable difficulty has been found in attempting to relate the results of such laboratory experiments to conditions in the field. Observations have shown that, even with a heavy clay soil, when the surface layers are puddled artificially the cap so formed is seldom completely impervious to oxygen diffusion.

Problems connected with the harvesting of root crops continue to receive attention. Progress has been made in harvesting potatoes by lifting them whilst still attached to the haulm. It is hoped that this method will lead to an easier separation of tubers from stones and clods, but clearly the success of the method depends largely on the potato varieties, since only those in which the tubers remain firmly attached to the haulm are likely to be suitable. The plant breeders are being encouraged to select such varieties. With a Dutch variety, it has proved possible to lift slightly more than half the crop by the haulm when fully mature.

A vegetable and root harvester has been devised in which a pair of driven rotary crop gatherers are used, and a primary elevator conveys the crop into stillages. This machine has proved to be very successful in trials with carrots, sugar beet, turnips and beetroot, but will require modification before it can be used for lifting leeks and onions.

The Institute has for a number of years undertaken investigations on the mechanisation of the sugar beet crop on behalf of the Sugar Beet Research and Education Committee. The main effort has been devoted to the problems of spring mechanisation, in which there is a need for precision drilling of seed, mechanical thinning and the control of weeds. The recent introduction of monogerm sugar beet seed has emphasised the urgent need for the development of precision drills although, at the same time, it has reduced the effort required for singling.

During the year under review, a small-scale trial was laid down at Wrest Park in which " complete " spring mechanisation was attempted by combining the use of monogerm seed with chemical and mechanical methods of weed control, followed by machine thinning. The results show that the use of monogerm seed, combined with machine thinning, achieved a final plant population having over 90 per cent single plants without hand thinning. All the chemical and mechanical treatments effected savings in labour of up to 50 per cent at the expense of about 10 per cent of the potential yield in comparison with normal hand singling.

The serious accumulation of dirt tare at sugar beet factories is another problem requiring urgent attention. At the present time far too much dirt is transported to the factories with the crop, and the Department is developing a cleaner-loader which will reduce dirt tare to a manageable level.

The Department has also, for a number of years, concerned itself with the development of specialised machines for tropical agriculture. In cultivation experiments carried out in Tanganyika, the advantages of tie-ridging over flat ridging in a maize crop were clearly demonstrated. A groundnut harvester has recently been shipped for trials to the Sudan Gezira, and potato harvesting equipment has been sent to St. Vincent to be used in the harvesting of arrowroot.

Harvesting Department. As part of the re-organisation it was decided that a new section should be set up in this Department which would be concerned with the bulk handling of crops. Work is therefore being started on bulk handling of a number of crops not previously under investigation at N.I.A.E., and studies on the processing and handling of apples in field and store are being continued in collaboration with East Malling Research Station and Ditton Laboratory.

The main interest of the Department continues to be in the harvesting, handling and storage of cereals, hay and potatoes. The need to reduce damage to crops is becoming of greater importance as the result of increasing complexity of harvesting techniques. The work with cereals has been extended to include a study of the actual physical characteristics of the individual grains that make them more resistant to damage, and also the maximum impact loadings that such grains will withstand. Results from preliminary experiments indicate that the moisture content of the grain at the time of threshing, grain size, shape and texture, all have an influence on the magnitude and nature of damage.

Studies on the barn-drying of hay have revealed a wide variation in moisture content, which is partly attributable to a lack of uniformity in the density of bales going into the drier. The major controlling factor, however, appears to be the method of swathing and tedding ; the use of a modified flail-type forage harvester greatly speeds up wilting of the hay and, consequently drying in the field.

Machine Performance Department. During the year 33 individual tests were carried out on a wide variety of different implements, ranging from a baler to electric fencing equipment.

A series test of combine harvesters covering 3 self-propelled and 1 trailed machine was carried out. Several manufacturers requested individual tests on forage harvesting equipment, the results of which can also be regarded as a series test since many of them were obtained under the same conditions and can fairly be compared.

The techniques used in the Department are being kept under continuous review so that modifications can be introduced to increase the efficiency of testing.

Metals and Materials Section. The formation of this section was one of the major developments of the re-organisation plan, for it represents a new field of enquiry for the N.I.A.E. which the Visiting Group considered to be very important to the needs of the industry.

Studies are already in progress on the wear of materials due to soil abrasion, in collaboration with the Cultivations Department, and these will be expanded to take into account all the different metals used in the manufacture of agricultural machinery, and will later extend to include other materials such as plastics.

Environmental Control Division

There are three main Departments in this Division, and smaller sections concerned with irrigation, physics and spraying machinery.

Growth Chamber Department. Plant scientists have long felt a need for facilities for growing plants under conditions in which the environment can be controlled. In America and on the Continent this has been met by the provision of extensive facilities at a small number of centres which have come to be known as "phytotrons". In 1958 a Working Party of plant physiologists was formed to advise the Agricultural Research Council on the requirements for controlled environment facilities in this country. The Working Party concluded that it would be preferable to provide more modest equipment at a larger number of centres rather than to concentrate all the available resources on building a phytotron. The N.I.A.E. was therefore asked to initiate research on the control of environment for plant growth, and a separate department was set up for this purpose.

The Department has been occupied over the past four years on the design and development of a controlled environment cabinet in which the space available for plant growth is a 4ft. 6ins. cube. By the use of a double-bank of fluorescent tube lights, it has been found possible to achieve light intensities of the order of 3,000 foot candles at the level of the growing plant. Furthermore with the aid of internal reflecting surfaces, the loss of light intensity in the height of the cabinet has been kept down to not more than 20 per cent of that immediately under the lights.

Preliminary air-conditioning experiments were carried out in the first cabinet built at Wrest Park and, as a consequence, it was possible to build a second cabinet with improved air-tightness and modulating controls.

Tests are now nearing completion on the first commercial prototype of the cabinet, and when these are successfully completed it is expected that the cabinet will go into commercial production and will be distributed to a number of research centres. It is intended that the first of the production cabinets should be installed in the Council's Unit of Flower Crop Physiology at the University of Reading, Department of Horticulture, of which the Honorary Director is Professor O. V. S. Heath, F.R.S.

Glasshouse Department. This Department is involved in studies on the design, heating and ventilation of glasshouses, with the object of improving the systems currently used in commercial practice. Automatic controls for heating, ridge ventilation and side ventilation have been installed in a new compartmented glasshouse at Wrest Park. Good control of temperature in space and time has been achieved, and a constant level, varying not more than $\pm\frac{1}{2}$°F, can be maintained except for transient errors due to sudden changes in external conditions.

Many commercial glasshouses are built as multispan blocks with inadequate ventilation, and it is customary to apply shading to the glass during the summer months to avoid unduly high temperatures. Recent experiments have shown, however, that, for tomatoes, better yield and quality result from the use of unshaded glass. This has raised the problem of improving the ventilation in existing designs of glass houses, and it appears that this may be achieved by increasing the angle of opening of the ventilators. Full advantage of the improved ventilation can only be taken if automatic control is also installed, and a unit designed at the N.I.A.E. for this purpose is now available to growers.

Plant Physiology Department. In the design and development of commercial glasshouses with efficient heating and ventilating systems, full account has to be taken of the effects of plants on the glasshouse environment and a plant physiologist was appointed to N.I.A.E. in 1959 to study these effects. Particular attention has been paid to the tomato crop, and, to co-ordinate research on the tomato crop grown under glass, a Tomato Growth Research Group has been formed with representatives of the three Institutes concerned with research on tomatoes, the Glasshouse Crops Research Institute, the John Innes Institute and the N.I.A.E.

A study has been made of the effect of night-time temperature on tomato growth and development, and its interaction with light intensity and age of plant. Restriction of root growth is another factor that may affect plant development directly, or it may limit the water supply and so have an indirect effect. Its interaction with water regime is therefore being studied in collaboration with the Glasshouse Crops Research Institute.

The Department has been investigating one of the common practices among tomato growers, the maintenance of so-called " day pipe heat ". This involves the use, during the period from sunrise to noon each day, of pipe temperatures higher than those required to maintain the desired air temperature, the excess heat being dissipated by opening the ventilators. The practice is claimed to give higher yields and better quality fruit, but in experiments carried out at two Experimental Horticulture Stations, no economic advantage was gained by its use, and it seems probable that any apparent advantages that have been achieved in commercial practice can largely be attributed to higher air temperatures within the glasshouse.

Another problem that complicates experiments in glasshouses is the shading effect of the glazing bars. This effect can be overcome by the use of diffusing glass but it was not known whether this type of glass reduced light transmission. An experiment was carried out, therefore, in which two glasshouses were used, one of which was glazed with diffusing glass and the other with clear glass. No difference could be detected between the two types of glass in the proportion of daily radiation used for transpiration.

Irrigation Section. The interests of this Section are at present confined to problems of automatic watering of crops under glass, although it is hoped that the programme may be broadened to include studies on the specification of irrigation equipment for all horticultural and arable crops.

In commercial practice various systems are used to determine the water requirements of crops under glass, including measurement of water loss from plastic containers and measurement of solar radiation. Recently, the main effort of the Section has been devoted to the development of a system of measuring soil moisture tension in an instrument which can be used to control automatic watering ; this is known as a tensiostat. Unfortunately, because of the marked variability between plants in their water requirements, it is difficult to achieve precise control with a single tensiostat. Progress in the development of this control system is therefore likely to be held up until more information is acquired on this problem and on the movement of water in glasshouse soils.

The Section has given some attention also to the automatic watering of pot plants, and this has been achieved by the construction of a constant level bench for capillary watering.

Physics Section. In the past this Section has concentrated on the investigation of the suitability of transparent plastic materials as substitutes for glass. In experiments to compare the heating requirements of Dutch light houses glazed with glass and with polyethylene film, no marked difference was found for equal air temperatures.

Of 32 samples of plastic film exposed to a weathering test for three years only 6 survived intact. The thinnest film of these 6 was made of polyethylene terephthalate.

In future, the major interest of the Section will be in the measurement of light transmission in glasshouses and in growth cabinets. An apparatus using two solarimeters and a resistance bridge has been devised which permits the direct continuous measurement of radiation transmission in glasshouses, whilst allowing for the fluctuations in intensity which nearly always occur. This has made feasible the determination of variations in transmission at a fixed point due to changes in external conditions, and the comparison of transmission at different points under similar conditions.

In order to give more precision to the measurement of light intensity, there is a need for the development of light meters that are more sensitive, particularly in those wavebands of importance in photosynthesis and control of growth, and attention is being given to this problem.

Spraying Section. Orchard spraying trials were carried out in Somerset between 1959 and 1961 using an N.I.A.E. designed spraying machine. The results of these trials have demonstrated that there are still outstanding engineering problems to be solved in providing a single machine for growers that is capable of both high volume and low volume (25-50 gal/acre) applications. In collaboration with scientists from East Malling and Long Ashton Research Stations, a tentative programme has been drawn up to intensify the study of certain detailed features of orchard spraying machinery. These include:— (1) fan design and efficiency ; (2) high velocity/low volume versus low velocity/ high volume spraying ; (3) the special problems presented by orchards with tall and dense trees.

Information Division

At the time of the re-organisation, the opportunity was taken of bringing together in one Division the work of the Survey Section Scientific Intelligence Unit, Library, Photographic Section and Public Relations Section.

Survey Section. The Section has continued to assist the Potato Marketing Board, in collaboration with the Ditton Laboratory, in the survey of potato damage through handling between field and retailer. A survey of damage to combine harvested wheat and barley was carried out at the request of the Harvesting and Handling Department.

In 1960 the Section started a small pilot survey of the operation of forage harvesters on the farm. This has provided valuable information on the durability of machines and their component parts in farming practice and has proved extremely useful to the Institute in planning the new users' testing service, to which reference, has already been made.

Scientific Intelligence Unit. The Unit is responsible for the preparation and publication of Horticultural and Agricultural Engineering Abstracts, towards the cost of which the Commonwealth Agricultural Bureaux make a substantial contribution. The Unit also provides editorial staff for the Journal of Agricultural Engineering Research.

The functions of the remaining three Sections are implicit in their titles, although it should perhaps be explained that the Photographic Section is concerned solely with the use of cine and still photography for research purposes.

Grain and Seeds Unit

As a consequence of the re-organisation, the research on bulk handling of grain, including studies on conveyors, which had formerly been done in the Grain Department, was transferred to the Harvesting Department set up in the Mechanisation Division. The remaining work of the Grain Department is being continued for the time being in this separate unit.

A number of engineering problems connected with the cleaning and storage of grain are under investigation both in the laboratory and in field experiments.

Commonwealth Liaison Unit

This Unit, which is supported by the Department of Technical Co-operation provides an information service to overseas territories on the advice and facilities which can be provided by the N.I.A.E. Research work undertaken by the Institute on behalf of overseas governments is financed either from local funds or by grants from the D.T.C.

Horticultural Engineering Research Unit

Since the re-organisation involved the more rational distribution of research between departments concerned with particular mechanised operations, such as cultivations and harvesting, rather than with specific crops, it was considered more appropriate to divide the work of the former Horticultural Engineering Department between the three research Divisions. For example, research on irrigation equipment and spraying machinery has been transferred to the Environmental Control Division, and that on the 2-way cultivation tractor to the Mechanisation Division.

Despite the redistribution of the work there has been no reduction of research effort in the field of horticultural engineering.

Scottish Station

The Scottish Station has not been affected by the re-organisation although, as at Wrest Park, the character of the work has changed over the years until now more time is spent on research, experiment and development than on testing. Whilst many of the research projects of the main Station are shared by the Scottish Station, much of the work is directed at machinery specifically intended for use under Scottish conditions.

The Station is under the direction of Mr. W. J. West and there are two Sections:— the Agricultural Section under Dr. I. M. Robertson, and the Engineering Section under Mr. G. Gilfillan.

Agricultural Section. This Section is responsible for the testing of all farm implements and machines other than tractors, the testing service being integrated with that at Wrest Park. The Director hopes to extend the use of series tests.

Since much of Scottish agriculture is concerned with the exploitation of marginal land, the main effort of the Section is devoted to studies concerned with land cultivation and land improvement. These include the assessment of alternatives to the standard mouldboard plough, the development of methods for dislodging and removing large boulders, and the use of mechanical and chemical methods for the control and eradication of bracken.

The Section is also interested in problems of transport on hill land. The application of lime and fertilisers to hill grazings involves transporting materials over steep slopes and often wet ground. A novel type of two-wheel trailer has been devised in which the tractor drive is transmitted to the trailer wheels if the trailer wheels begin to slip. This is now being subjected to exhaustive field trials.

With the move to the Bush Estate it has been possible to initiate a study of the effect on soil structure of tractor and trailer wheels and different types of cultivating equipment. Preliminary investigations have shown that methods of cultivation can have a profound effect on soil structure, for example, on the formation of clods in potato crops, and hence on one of the acute problems of mechanical potato harvesting. A physical and mechanical examination of various soil types and a study of methods of redistributing tractor wheel loading should lead to a reduction in soil compaction and clod formation. This investigation will take full account of the fundamental work on soils which is in progress at Wrest Park and elsewhere.

The wet conditions which persist in Scotland at the time of the cereal harvest have stimulated interest in the use of swath harvesting methods. The Section has developed a swath harvester which has been compared with a direct combine harvester in field trials. A roller type aerating machine is also being developed for use after swathing when the crop is slow to dry. This should find application in the wetter conditions of the west.

A rubber-spool type potato grader which was designed by the Section has now been developed commercially. It compares very favourably with other graders, giving a grading accuracy of 95 per cent with a through-put of 5 tons an hour. With the market demanding increasingly precise grading for prepacks, this machine should prove popular with farmers.

Engineering Section. The Section's main work is concerned with the drying of grain, with particular emphasis on grain of high moisture content such as is commonly experienced with the grain harvest in Scotland. An experimental drying plant has been designed and constructed in which 2-3 ton batches of grain can be dried simultaneously, with up to 5 different treatments. It is intended that the equipment will be used later to determine the optimum conditions for drying loose and baled hay.

Mention has already been made of the need to avoid clod formation in cultivating potatoes. A 3-row mounted rotary ridger has been developed which successfully breaks down the soil without forming clods. Attention has

also been given to the use of chemical weed-killers to control weeds in potatoes, and this may be expected to reduce very considerably the movement of machinery through the crop and the consequent compaction of the soil.

The Section has devoted a very considerable effort to the problems of harvesting potatoes. A haulm-puller has been devised which effectively removes haulms so that they do not complicate the difficult job of separating tubers, stones and clods. This will be incorporated into the commercial harvester which has been modified to produce an even flow of potatoes and debris for separation by an electronic device. If the field trials are successful and it can be exploited commercially, it will represent a major advance in potato harvesting methods.

This Section is also responsible for farm trials of tractors in co-operation with Wrest Park. In the year under review, two tests were carried out.

GRASSLAND RESEARCH INSTITUTE

The Grassland Research Institute was established in its present form in 1949. It has forerunners, but the date of its foundation is a reminder that " grass " was late in receiving the organised scientific attention due to it as the dominant crop in British agriculture. Belated recognition of the possibilities of grassland improvement came very largely from the pioneer researches and missionary zeal of the late Sir George Stapledon at the Welsh Plant Breeding Station in the years between the world wars. Application was stimulated by the second war. In 1940, the Ministry of Agriculture and Fisheries set up a Grassland Improvement Station at Stratford-on-Avon with Sir George Stapledon as Director. This Station was at first more concerned with demonstrating the improvement of derelict lands than with research ; but as as soon as its wartime programme was completed the emphasis of its work changed. It continued for a few years as the Grassland Research Station, under the direction of Dr. William Davies, and then provided the nucleus of the new Institute which is under the same Director.

The present site at Hurley, near Maidenhead, Berkshire, was acquired for the prospective Institute in 1948 but, because laboratories and other buildings had to be erected, it was not fully occupied till 1955. The research programme, however, went on continuously as the staff was transferred gradually from Stratford and additions were recruited. The number of Scientific and Experimental Officers transferred was about 20. By 1955, the number employed had grown to 47 ; in 1961 it was 56.

Since 1955 the Institute has been consolidating its organisation and developing its long-term programme on the 600 acres of the Hurley farm and in its well equipped modern laboratories. The period has been one of steady progress, marked by an increasing output of scientific information and practical results influencing grassland husbandry.

The Institute works collaboratively with sister bodies in the agricultural research service whose interests overlap its own, such as the plant breeding stations and dairy research institutes, and with the grassland husbandry officers of the National Agricultural Advisory Service. It also has co-operative relations with the University of Reading, by which postgraduate students

working in its laboratories may be registered for higher degree of that University. Students and other scientific visitors come to Hurley from many countries, since the Institute's reputation has spread far beyond Britain, and, while making its chief impact on grassland practice in this country, it has undoubtedly had a considerable influence on grassland investigations overseas. The Commonwealth Bureau of Pastures and Field Crops is housed at Hurley, to the mutual advantage of both organisations, and helps the staff to keep in touch with research workers in other countries.

A brochure describing the development and work of the Institute was issued in 1960 on the occasion of the meeting of the Eighth International Grassland Conference at Reading. An annual report is published under the title "Experiments in Progress."

THE RESEARCH PROGRAMME.

The Grassland Research Institute studies all aspects of the composition, treatment and use of grassland swards as food for ruminant animals, and also the part played by the grass crop as a soil improver. To appreciate the variety of investigations covered by this brief statement it is necessary to remember some of the differences between grass (the term being used for simplicity to cover all the constituents of mixed swards, including herbage legumes) and arable crops. The first of these is that grass is not an end product of the farm: its chief use is as food for livestock and as such it is normally consumed on the farm on which it is grown, in contrast to crops like wheat or sugar-beet which are sold off the farm for processing elsewhere. The second is that grass has another important function in mixed farming by virtue of its effects on soil fertility; it is the key crop in the ley-arable system. In consequence of these two characteristics, many grassland problems are inseparable from problems of animal husbandry, and some are closely bound up with arable crop husbandry.

Two further attributes of the grass crop are especially significant in the planning of research to raise productivity. One is that grass is needed all the year round. Although part of a summer abundance can be conserved for winter use, there is a loss in the process which leads the grassland agronomist to aim at producing a continuous harvest with the least seasonal fluctuation that the climate will allow. The other is that, botanically, grass is not one crop but many. Whereas most arable crops are simple stands of a single variety, the grassland sward is normally a mixed community of plants of different species and varieties, all reacting differently to changes in the environment. Such a mixture is much more flexible and adaptable than a pure stand, but it is at the same time a much more complicated thing to study. Two sets of studies are in fact needed, one of the behaviour of the individual components of the sward and one of the behaviour of the community as a whole. The community is perpetually changing in composition in response to changes in environment—and in environment the grassland ecologist must include the grazing animal and its behaviour both as a defoliator and as a fertilizer.

In the light of these considerations it may be said that the ultimate objective of grassland research is to analyse, and learn how to manipulate, the whole complex ecological system formed by pasture plants, grazing animals and the physical environment. In practice, research must be concentrated on

more specific objects, selecting first the problems that appear to be of greatest economic importance. The Institute has always put high on its programme the extension of the grazing season, testing methods of sward management designed to provide grass in the field for out-of-season grazing and searching for new plants that will give winter growth. It has also paid special attention to the nitrogen needs of the sward and the complicated relations between fertilizer nitrogen and clover nitrogen. The nitrogen cycle in the soil under various ley treatments is a related though separate subject of investigation. The need to evaluate swards in terms of animal production has required a great deal of effort to be put into developing suitable techniques for the purpose, and this naturally entails experimental work on the management of livestock to make the best use of the grass crop. Another major topic is the digestibility of herbages and its variation with species, stage of growth and season.

By the nature of the questions to be answered, field experiments are a large part of the Institute's activities. The land is farmed on a ley system, the lengths of the leys and the pattern of arable cropping being determined by the demands of the research programme. Some 300 beef cattle and 1,100 sheep (at peak) are used in the experiments.

To ensure that field experiments yield basic information, and not merely empirical results, they are closely linked with the laboratory research necessary to probe the fundamental principles underlying grassland agronomy. The research team includes specialists in the various scientific disciplines that are employed, such as plant physiologists to study in detail the growth and development of herbage plants and biochemists to investigate their nutritive value.

The notes on departmental activities in the following paragraphs are no more than outlines, using selected details to illustrate the variety of problems receiving attention.

Herbage Agronomy. The Herbage Agronomy department, as the one most directly concerned with herbage production, has a primary interest in plant material and is always on the watch for new varieties, especially those that may extend the grazing season. It does not breed herbage plants, because the plant-breeding institutes are better equipped for that function ; but it works closely with the breeders in assessing their new varieties and in observing the behaviour of introduced species which may be useful breeding material. The department has had encouraging results from its introductions of exotic grasses, notably certain North African fescues which show a remarkable ability to grow in winter.

Herbage agronomy is equally concerned with the management of swards, including the use of fertilizers. Among nutritional problems the department is concentrating on nitrogen requirement, which is not only the most important but also the most complicated. In the mixed sward, some of the fixed nitrogen taken up by the grasses is supplied by the clovers, and one of the practical objectives of research is to make the best use of legumes as a source of nitrogen. Total herbage production may be stimulated, either seasonally or continuously by the use of nitrogenous fertilizers ; but fertilizer nitrogen affects the relative competitive abilities of the grasses and clovers and at some levels will lead to reduction in the supply of clover nitrogen. Determining the most economical

use of fertilizer nitrogen is therefore a many-sided problem ; and it is further complicated by the grazing animal which also affects the balance of grasses and clovers by its defoliating action and by excreting nitrogen in its dung and urine. Manurial experiments with nitrogen are therefore closely linked with studies of the role of clover in the sward.

Since selective herbicides were first introduced the department has, in collaboration with the Weed Research Organisation, experimented with their use in controlling the composition of grassland swards.

This line of research has taken on added importance since the introduction of compounds that will kill, at suitable concentrations, grasses selectively or give a complete kill facilitating resowing without ploughing.

Plant Physiology. The plant physiologists study the growth and develop- of herbage plants in detail in order to gain insight into the principles that govern the behaviour of swards under field conditions. Their work is thus complementary to that of the herbage agronomists, with whom they co-operate. They have observed, for example, the development of tillers in several species of grass under different conditions and followed carefully the life-histories of individual tillers to learn precisely how the single grass plant grows and contributes to the herbage yield of the sward. The growth and development of white clover plants have been studied in a similar way. The department is currently engaged in an analysis of pasture regrowth after defoliation, with the object of finding out whether it depends more on reserves in the plant or on the area of leaf remaining for photosynthesis after the top has been removed. The answer will have an obvious bearing on sward management and illuminate the results of field experiments by the herbage agronomists on the effects of intensity of grazing on yield.

The department also studies the physiology of flowering and seed production in grasses, having in mind various practical problems of the seed grower as well as the significance of relations between vegetative growth and flowering in connection with herbage production. Other subjects of investigation include the physiology of root systems and nutrient uptake. Research is done as far as possible under field conditions, but for many purposes it is necessary to control the environment either partially, by working in the greenhouse, or more completely by using growth cabinets. All three methods are therefore used as appropriate.

Ley Agronomy. The main interest of this department is in the effects of the grass crop on soil fertility. These effects are investigated in the field by measuring the yields of arable crops following leys of various botanical compositions and variously managed, and in the laboratory by studies of the changes in certain characters of the soil during the rotation of crops in ley arable experiments. The researches to date have led to the conclusion that the major effect (which is shown most strongly in the first arable crop following the ley) is attributable to increase in soil nitrogen. The emphasis in current work is therefore on the nitrogen cycle in the soil while it is under grass, and this research is closely related to that of the Herbage Agronomy department on clover nitrogen and nitrogen fertilizers.

The Ley Agronomy department is also interested, from more than one point of view, in root growth. Its early work on the subject was designed to get information about the development of the root mass under leys, with reference to seasonal production and to distribution in depth. As roots represent an important source of organic matter, the breakdown of which contributes to the soil nitrogen, these studies are a necessary part of the investigation of the nitrogen cycle. At the same time they connect with experiments in grassland irrigation which the department has been conducting since 1955.

The use of herbicides to kill swards, as an alternative to ploughing, interests Ley Agronomy as well as Herbage Agronomy. Experiments have been started to investigate the possibility of growing arable crops after leys killed with herbicides, without disturbing the soil deeper than is required to sow the seed ; and in the first of these it was found possible to establish winter wheat with the minimum soil disturbance and to produce yields similar to those obtained by ploughing and seedbed preparation in the conventional manner.

Microbiology. Two subjects of close interest to the Ley Agronomy department have been studied in the small Microbiology section. One is a microbiological analysis of the soils from the department's main field experiment, to see whether changes in the soil microflora can be correlated with those in nitrogen status. The other is a study of the rate of decomposition of various organic materials in the soil, beginning with a comparison of cocksfoot and ryegrass.

Biochemistry and Animal Nutrition. The practical objective of this department is to assess the quality of various herbages as food for livestock. Its researches thus link those of the departments engaged on problems of herbage production and those of the departments primarily interested in the animal products of grassland.

The department has concentrated in the first place on digestibility, which is measured by feeding trials with sheep. It has found that digestibility varies both between herbage species and with stage of growth, and has traced the changes in digestibility with age for several of the more important species. It has also studied the digestibility of hay and silage. An important recent advance has been the development of a technique for estimating digestibility in the laboratory on much smaller quantities of material than are necessary for feeding trials. This method has many advantages and promises to be of special value to plant breeders as it opens new possibilities of breeding more digestible herbage varieties.

Concurrently the biochemists are trying by several methods of approach to throw further light on feeding values. They are studying the chemical composition of herbage plants, especially their carbohydrate and amino-acid constituents, and investigating the effects of different herbages on the proportions of the volatile fatty acids produced during fermentation in the rumen. All this work is aimed at securing better control of the quality of herbage grown to feed farm animals. In addition to its own programme, the department provides a chemical service for the whole Institute, performing some 40,000 analyses a year, of various kinds, for the agronomists.

Animal Agronomy. The functions of the animal agronomists are to evaluate grassland swards in terms of animal production and to test systems of livestock management designed to make the best use of grass. They share

the herbage agronomists' interest in the composition and management of swards, but approach the problems of management from the complementary point of view of the user, seeking the most profitable ways of converting herbage into liveweight gains of cattle and sheep.

In the evaluation of swards, the first need is to develop suitable techniques for the purpose. Much work has been put into this in the past, and there is always more to be done in improving accuracy. It is necessary, for example, to estimate the herbage intake of animals at pasture, both in quantity and in quality. This is one of the problems studied by the department in close co-operation with Biochemistry. Attention is also given to carcase quality in assessing the value of swards and management methods.

Current subjects of investigation include the management of calves put to pasture at an early age ; comparisons between " bred " and " commercial " grass varieties, and between permanent and reseeded pastures ; effects of frequency and intensity of grazing on the production of fattening cattle ; and effects of various methods of overwintering on production from different types of sward.

Grass/Animal Ecology. This department was set up in 1958, as an offshoot of Animal Agronomy, to give special attention to problems arising in the management of animals at high levels of production. One such problem is the control of internal parasites. Work had begun several years earlier to investigate the effects of worm burden in sheep on their rate of growth and productivity, and to find methods of grazing management that would minimize infestation of lambs. The results led to three significant conclusions ; first, that the growth of lambs reared so as to be relatively free from worm infestation was superior to that of a similar group allowed to become lightly infected ; secondly, that infestation could be largely controlled by suitable methods of management ; and thirdly that the presence of parasites is a serious complication which greatly reduces the precision of many experiments with sheep.

The Department is extending this work into a wider study of the interrelations of grass, grazing animal and parasites with the object of matching a high level of animal production to the enhanced grass production achieved by advances in herbage agronomy. It is most concerned with fat lamb production. A small flock of sheep relatively free from worm infestation has been built up and is maintained with suitable precautions in a " worm-free " area, where various experiments can be made with a precision that would be impossible if worm-infested animals were used. One of the studies is an evaluation of pasture at different times of the year. An essential part of the work on intensive lamb production is a study of early weaning and artificial rearing methods.

In a related experiment fat lambs are being produced year after year on the same ground (not " worm-free ") to assess production per acre per annum, with a watch on the incidence of parasites and on the botanical effects of close grazing on the pasture. Some attention is also being given to pasture management in relation to lung-worm infestation of cattle and to associated problems of calf-rearing.

Extra-Mural Experiments. To test conclusions reached at Hurley under a wider range of conditions, arrangements are made with farmers in various parts of the country to accommodate experiments supervised by Institute staff.

In recent years these have dealt largely with the extension of the grazing season, using different grass species and varieties with various fertilizer and management treatments for producing herbage out of season. The present emphasis is on the grazing animal in winter, testing herbage utilisation by different classes of stock under extremes of climate in the north-east and south-west of England. This work is done in close collaboration with the National Agricultural Advisory Service.

Biometrics. A small department provides a statistical service for the Institute, advising and assisting in the design of experiments and the computing of the results. It also does research on statistical methods applicable to the kind of experiments that most concern the Institute, especially grazing experiments.

NATIONAL VEGETABLE RESEARCH STATION

During the latter part of the 1939–45 war with its urgent need for increased food production, the national interest in vegetable growing was accentuated and the limitations of the facilities available at the Horticultural Research Institute at Cambridge became evident. A survey group appointed by the Agricultural Research Council, the Agricultural Improvement Council, the Ministry of Agriculture and Fisheries and the Scottish Agricultural Advisory Council recommended that a new vegetable research station should be founded to serve this important industry. Currently, the value (to growers) of vegetables produced in the U.K. is of the order of £75M. per annum ; if amateur gardners are included the figure is estimated as approximately £100M.

The National Vegetable Research Station (N.V.R.S.) at Wellesbourne, Warwickshire, and its Sub-Station at Paglesham, Essex, were established under a governing body incorporated in September, 1949, as a company limited by guarantee, with the title " The British Society for the Promotion of Vegetable Research ". A farm of 280 acres at Wellesbourne was selected after a careful survey of many possible sites. The soil, like that in the nearby Vale of Evesham, is mainly a medium sandy loam of reasonable uniformity and had not previously been used for the intensive cropping of vegetables, Market garden crops are rotated with cereals and leys, using a herd of about 80 Hereford bullocks for grazing. A breeding and feeding herd of Large White pigs, providing about 300 baconers per annum, is also maintained. A further 95 acres of land was incorporated in the farm in 1959. The land at Wellesbourne is level and well suited to field experimental work. The situation of the station is convenient for both staff and visitors and is close enough to Birmingham University to enable academic connections to be maintained. The Sub-Station at Paglesham in Essex comprises 150 acres of land suitable for raising seed crops and for undertaking special studies on seed production.

Work at the station is in progress on all the commonly grown vegetables. The needs of the amateur, the small holder and the market gardener receive attention as well as those of the specialist farmer with a large acreage and the seed producer with his special problems.

In more recent years the requirements of the canning and freezing industry have become increasingly important and have accentuated the need to take into account the demands of the consumer in all research on crops grown for direct human consumption. Although the yield of vegetables must always be a primary consideration, the search for high yielding varieties and cultural methods which produce high yields cannot be pursued regardless of quality in its broadest sense. Quality embraces flavour, colour, texture and size, and can usually only be assessed by subjective methods which require the most careful planning and interpretation.

Since the establishment of the Station a team of research workers and assistants has been carefully built up and now comprises a scientific and experimental staff of 45 officers. The Station is one of the youngest in the family of agricultural research institutes and, although it had previously received a Visiting Group in 1955, when the staff were still working in huts, the Group appointed in 1961 was the first to visit the Station following its establishment in permanent laboratory buildings. The Group was well pleased with the way in which the Station had developed. A suitable balance between investigations of the immediate problems of the vegetable growing industry and longer-term basic research has been achieved and the Station has already contributed to the solution of several practical problems while at the same time laying the foundation for further advances. In particular, the Group noted good co-operation between sections ; this is of paramount importance in the investigation of biological problems, which almost invariably involve several different scientific disciplines.

In this short review of the work of the National Vegetable Research Station only the salient points of development and progress can be mentioned. Further information may be obtained from the annual reports of the Station which have been published since 1950.

Plant Breeding

This section has followed a realistic policy designed to assist the seed trade to provide improved seed for the use of vegetable growers. Few seedsmen can afford to undertake complex plant breeding work and certainly no research station can undertake to provide sufficient seed for a whole industry. Co-operation between research stations and the seed trade is established through the National Institute of Agricultural Botany, who carry out extensive field trials and preliminary multiplication of stocks. By this means adequate quantities of seeds of improved and certified varieties for the use of both commercial growers and amateurs are provided.

The section has an extensive programme and, as may be expected, the rate of progress is variable in different projects. With Brussels sprouts, cauliflower, lettuce and peas the new varieties produced have reached the stage of inclusion in national trials. Selected varieties of Brussels sprouts in commercial use have been inbred and selected over several generations with improvement in desirable characters but with up to 40 per cent loss of vigour (yield). Hybridisation has restored the full vigour and the first generation (F1) hybrids produce heavy yields of uniform medium-sized sprouts, which can be picked over a period of three months and which do not " blow " (i.e. the sprouts remain tightly closed like the heart of a cabbage). The uniformity

of these sprouts is a particularly valuable feature as 90-95 per cent are marketable as compared with 60-65 per cent in most commercial varieties grown at present. If all continues to go well with field trials the parents of these hybrids will eventually be interplanted by seedsmen in isolation (a minimum of 1,000 yards from other seed crops) to produce F1 hybrid seed. The seeds from cross fertilisation of both parents are alike, so that practically the whole of the seed crop may be utilised. Hybrids suitable for quick freezing are also being developed.

The lack of winter hardiness in wrinkled seeded (garden or sugar) peas has been a great disadvantage in the past. The hardiness of the Australian Winter Maple pea has been successfully bred by hybridisation into current commercial types such as Onward and Dark-skinned Perfection and the new type, which is self fertile, will breed true, survive the winter and come into bearing 2 weeks earlier than any at present available. Tasting, quick-freezing and canning tests have been satisfactory and indicate possibilities for extending the processing season by at least two weeks.

Work on beet, onions and celery is also making good progress. Potential new varieties of red beet and onions are ready for national trials.

Physiology

Size is undoubtedly one of the most important factors in the quality of vegetables, especially with crops required for pre-packing, canning and quick freezing. Studies of the spacing of vegetable crops carried out in this department have resulted in the development of cultural techniques which not only produce vegetables of a size most suited to consumer needs but also give very high yields. Growers have been quick to see the advantages of close row systems of planting and the work in this section has already had a marked effect on commercial practice, especially with carrots.

Success with the elimination of weed competition by cultural practices and the use of herbicides has stimulated the study of competition between the crop plants themselves and, with the co-operation of the Statistics section, the physiologists have made detailed studies of the effects of plant density and pattern of plant arrangement on yield, size and uniformity of crops. An example may be taken from experiments with carrots in which the more nearly square was the pattern of arrangement of the plants, the higher was the total yield produced. Continuous variation in row width and seed rate was used to give three types of plant layout. In the first the plants were in a fixed arrangement with a ratio of between-row/within-row distance (rectangularity) of 9·5 : 1 but with the density ranging from 1 to 50 plants per square foot. In the second type of layout the plants were kept at constant density (10 per square foot) but with variable arrangements (rectangularities of 70 : 1 to 1·5 : 1). The third type of layout was exactly similar to the second except for a higher plant density of 39 per square foot. In the first type of layout yields rose with increasing density and at a second harvest on the 24th October had attained 53 tons per acre compared with 12 tons per acre from 1 plant per square foot. 93 per cent of the yield of 53 tons was of a marketable size and of this 38 per cent was suitable for canning as whole carrots. In the second and third types of layout, decreasing the rectangularity from 70 : 1 to 1·5 : 1 increased the

total yield at the early harvest on the 5th September by 80 per cent and 94 per cent when the plant densities were 10 and 39 per square foot respectively. The corresponding figures at the later harvest on the 24th October, after a longer growing season, were 67 and 38 per cent.

In other experiments it has been found that at all row spacings a 4 lb. sowing rate gave about 65 per cent and 125 per cent greater yield of canning size roots at a first and second harvest respectively than did a 2 lb. sowing rate. The proportion of the total yield which was of canning size was similar at all row spacings at a first harvest, whereas at a later harvest the proportion tended to be greater from 16in. rows than from 4in. rows because the wider row spacing restricted root growth. Thus these data indicate that, in order to restrict root size whilst retaining the yield advantages afforded by the use of 4in. rows, higher rates of sowing than 4lbs. per acre would be needed.

Similar experiments with onions and peas have taken full account of the profitability of crops calculated in terms of grading percentages and market value and the cost of planting and the cost of seeds or sets. The maximum gross yield is not necessarily the most profitable ; optimal spacings can be determined to give the best combinations of yield and quality.

This work is raising new agricultural engineering problems, such as the provision of drills suitable for close spacing, side harvesters which minimise damage to crops and of spraying and irrigation equipment which will operate efficiently under conditions where access is limited by spacing arrangements. These problems are being studied by the National Institute of Agricultural Engineering.

The spatial arrangements of plants obviously affect the availability of nutrients, water and solar energy to individuals in the population. Growth rate studies are also being undertaken in which it is hoped to distinguish treatment effects from year-to-year weather effects. High densities of plant population must increase the demand for nutrients and water, and possibly render closely spaced plants much more susceptible to drought than would the traditional methods of culture. The staff of the Station work as a team in tackling such problems and the Physiology section is working with those of Chemistry and Irrigation, assisted in all stages of the planning and analysis of field experiments by the Statistics section.

Another example of closely integrated efforts by the Station's staff is to be found in this department's concern with seed production which is obviously of the greatest importance to the final success of the plant breeders' efforts, and with measures taken to eliminate diseases which are not transmitted through seeds (*vide* Pathology Section). The effects of various manurial treatments, plant spacing and weather on the yield and quality of seed are being studied. The quality of seed involves experiments with time of harvesting, temperature of drying and the effect of such factors on germination and subsequent vigour of growth.

Other work in this section includes the investigation of the internal browning of Brussels sprouts and the use of plastic films as glass substitutes or for mulching.

Chemistry

In the broadest terms the Chemistry section is concerned with the chemical and physical factors affecting the fertility of soils.

Current work includes problems of immediate interest to growers, long-term experiments with manures, cultivation practices (often by co-operation with other sections) and objective basic research on soil aeration.

Growers have quickly adopted recommendations based on the Station's work for top dressing spring cabbage crops with nitrogen at rates which appear high but which have proved to give very worthwhile returns.

In many experiments farmyard manure has proved to be especially effective on most vegetable crops and cannot be replaced entirely by mineral fertilisers. Results with farmyard manure are however very variable and the reasons for its effect and variability are being explored. This effect is almost undoubtedly a complex one but some possible factor of special interest in current research, one being an apparent ability of farmyard manure to supply the amounts of potassium required by young seedlings for their most rapid growth. Another factor is its ability to increase the amount of soil moisture available to plants. Farmyard manure is generally supposed to have physical effects on soil structure in addition to a capacity for supplying readily available plant nutrients. The soil at Wellesbourne is well suited to a study of such effects and soil aeration is another condition receiving the closest attention.

At present, there are no means of finding whether the growth of crops in the field is being restricted by poor aeration. Aeration influences the growth of plants either by affecting the ability of plant roots to reach or take up soil nutrients, or by regulating microbial activities and, in consequence, the amount of available nutrients in soil. Studies have been made both of the effects of oxygen concentration on these microbial activities and of the ability of plant roots to absorb available nutrients. Methods are also being developed to determine the distribution of oxygen in soil. It has been found that a simple relation exists between oxygen concentration and microbial activities and that poor aeration reduces the growth of cabbage seedlings by restricting root penetration. Equations have been developed, and their validity tested, for showing how the distribution of oxygen is affected by diffusion into and between soil crumbs and by their shape and size. In this way, good progress has been made in developing a procedure for determining, from easily measurable soil properties, the extent to which the growth of crops in the field is restricted by poor aeration.

During the course of nine years of field experiments, areas of the farm with different cropping histories have developed widely differing levels of fertility. These areas are now to be used in co-operative experiments that are referred to in describing the work of other sections.

Pathology

A particularly happy example of the immediate value of agricultural research, readily assessable by reason of the compact nature of a specialised section of industry, is to be found in the control of Crook root disease of watercress. Although the highly organized production covers only about 500 acres the value of the watercress is of the order of £2,000-£4,000 per acre each year.

After a long history of apparent freedom from diseases, dwarfed or dying plants showing a characteristic distortion of roots were first seen in Wiltshire in 1948. The disease became wide-spread and losses became so great as to make many beds quite uneconomic and by 1950, when research was started on the disease, it was apparent that some method of control was urgently required. Mycological investigation showed that the crook root condition was caused by a fungus and transmitted by zoospores which swam through the water in the beds. During the study of the disease a fortunate chance led to the discovery that minute traces of zinc (0·1 parts per million) introduced into the water would kill the spores and from this a method of control has been developed. If the beds are fed from a central supply the zinc can be applied in the form of a solution of zinc sulphate. For beds which receive their water from a number of sources it is necessary to apply a compound that will release the zinc very slowly. This is achieved by dissolving zinc oxide in glass, which is then finely powdered. This "zinc frit" is scattered on the floor of the cress bed and gives very satisfactory control. Very slight excesses of zinc induce an iron deficiency, but precise methods of zinc application have been satisfactorily evolved.

The traditional method of propagation of watercress has been a vegetative one but, during the course of the Crook root investigation, an aphid-transmitted virus disease related to turnip mosaic was discovered in the commercial stocks of watercress. The reduction of vigour by this virus infection was estimated to cause a 30-40 per cent loss of yield. The virus is not seed-borne and co-operation between departments in the Station has resulted in the improvment of seed production and at the same time has provided an opportunity for selection of improved types of cress.

A disease of lettuce known as "Big Vein" has proved to have perplexing characteristics, some of which point to a fungal origin and some, quite contrarily, to a virus. During the course of work on this disease the first known transmission of a graft transmissible causal agent (most probably a virus) through a fungus has been achieved and thus extended basic knowledge of the behaviour of plant pathogens.

Mosaic disease of lettuce is caused by a virus which is transmitted through seed and is then spread extensively through crops by aphids. This is causing much concern and has stimulated efforts to produce seed from virus-free plants grown in isolation. Laboratory studies have produced a serological method for rapid detection of the virus, which will aid the production of clean seed.

In recent years a valuable variety of beetroot, Cheltenham Green Top, has been in danger of extinction by a bacterial disease which causes silvering of the leaves of the seed crop. The commercial use of a seed treatment with a ·02 per cent solution of Streptomycin devised at Wellesbourne has almost eradicated the disease.

A method for the control of canker of parsnips is promised by selection of resistant types which are undergoing field trials.

Entomology

This section has also make a substantial contribution towards the solution of practical problems. Some 40,000-50,000 acres of carrots grown in the U.K. each year have in the past been attacked by the carrot fly and many

hundreds of acres have been so severely attacked that the crop has been ploughed in. The same pest may also attack parsnips and cause progressive damage through the autumn and early winter.

The biology of the carrot fly has been studied in detail on carrots and parsnips. It was found that the first developmental stage of the pest fed mainly on fibrous roots in early May and that attack by the second and third stages on the main root was not observable until late in June. The full extent of the damage did not become apparent until mid-July. Damage by the second generation followed in October. Complete control of all stages of attack was not gained until a persistent insecticide was intimately incorporated with the top four inches of soil at the time of sowing and much further work was required to eliminate all danger of affecting the flavour of crops grown under these conditions, and to find suitable dosage rates for all types of soil. The highly organic soils of the Fens, for instance, required twice the dosage rate effective in the lighter soils at Wellesbourne. When incorporated with soil some insecticides have proved to be surprisingly persistent and have remained effective for six successive seasons. The rate of decay of such materials may be as low as 10-15 per cent each year. Retreatment rates which maintain effective concentrations but avoid excessive accumulation of insecticide in the soil have been found by trial.

The importance of avoiding excessive insecticidal residues in soil is well illustrated by the effect of dieldrin residues, following the control of carrot fly, on ground beetles which eat the eggs of the cabbage root fly and which are a potent factor in the control of this serious pest of cabbages and summer cauliflowers. Under field conditions these beetles may take 60-90 per cent of the eggs of the cabbage root fly, thus very greatly reducing the number of larvae or maggots which may emerge and feed on the roots of brassica crops causing stunting or death of the plants. The predatory beetles, however, are more sensitive to the insecticide than the pest and damage caused by cabbage root fly may thus be increased in brassica crops which follow carrots grown in dieldrin treated soil.

Field experiments using barriers to restrict the movements of ground beetles and sensitive serological techniques to show which beetles have fed on the eggs of the cabbage root fly have enabled the details of the relationship between natural controlling factors and the pest to be worked out and have made it possible to devise methods for gaining full control of the cabbage root fly.

Another pest of carrots is also being studied. The insect concerned is an aphid which feeds on the plants in May and June causing severe damage which is then followed by leaf mottling and stunting, due to a virus disease which is carried by the aphid and transmitted to the carrots during the course of feeding. In July this pest migrates to other plants, including willows, where it spends the winter. Progress is being made with its control.

Another aphid pest also being studied in detail is a migrant from Lombardy poplar. It attacks the roots of lettuce and can cause severe damage especially under dry conditions. The mixing of diazinon into the soil before sowing lettuce has been found to give an effective control. Some lettuce

varieties have proved highly resistant to attack and, whilst offering in themselves a means of combatting the pest, have encouraged attempts to breed resistance into varieties of high market quality.

Irrigation

Irrigation of vegetables is proving very profitable to growers and the practice is spreading very rapidly. It is appropriate that the first section entirely occupied with irrigation in any A.R.C. organisation should have been started at the N.V.R.S.

Although methods for estimating irrigation needs in the field are available, they are not widely used at the present time because in general irrigation is used where water is cheap and plentiful and irrigation seldom fails to be profitable. From a longer term point of view the practice of irrigation in Great Britain is likely to be limited by water supplies and the section is therefore concentrating on the most efficient use of water and the possible elimination of the need for irrigation by devising suitable cultural practices embodying methods such as minimal cultivation and mulching.

One of the most important lines of work in this section is concerned with determining moisture-sensitive periods when maximum response to irrigation is obtained with some crops. With peas, for example, the yield is not affected by irrigation before flowering provided the seeds germinate in soils with their full field capacity for water satisfied in the spring, and provided there are no exceptional weather conditions which severely limit vegetative growth. After flowering, as little as ½in. rain fall or irrigation, a quantity which may be quite insufficient to restore the water content of the soil to full field capacity, will give a substantial increase in yield.

Potatoes and turnips also have marked moisture-sensitive periods but cauliflowers, lettuce and carrots do not. With cauliflowers, response to water is obtained at all stages of growth, including the seedling, and watering just before cutting substantially increases yield.

With the co-operation of other Sections, field experiments are being carried out to obtain a complete picture of water requirements of vegetables from the stage of seed bed preparation to maturity. In the spring when water supplies are normally optimal, irrigation to full field capacity offers opportunities for minimising requirements later in the season, especially if weed control is effective, cultivation reduced to a minimum and mulches of various types are feasible. Irrigation in the spring may also reduce frost damage.

If a crop is started off with soil moisture at field capacity, a reasonable yield is almost certain although it may not be maximal. Maximum yields are not however necessarily the most economic because the conditions which produce them may affect quality and flavour. For example, irrigated carrots though they may be attractive in appearance may at the same time lack colour, sweetness and flavour compared with unirrigated roots. Conversely, irrigated turnips, radishes and lettuces are crisper and mellower than plants grown under dry conditions.

Irrigation studies are also linked with the studies on crop spacing, in co-operation with the Physiology section ; very high populations of plants such as carrots, closely spaced to give high yields of small roots suitable for canning, naturally increase their demand for water.

This section is also carrying out some more fundamental studies of moisture availability in different types of soil and on the relationship between transpiration and yield.

Weed Investigations

Herbicides developed for use with cereals are not necessarily useful in vegetable crops because vegetables are usually damaged by such herbicides. Furthermore the weed flora and control problems in vegetable crops are different from those in agricultural crops. It is necessary therefore to study the specialised use of herbicides in vegetable culture. The work of this section is, however, done in close co-operation with the Agricultural Research Council's Weed Research Organisation. The residual effects of herbicides are especially important in growing crops in close rotation and may vary in dry and wet seasons, in winter and summer, and are also dependent on soil type. For example, a particular herbicide which disappears in 4 weeks during a hot summer has been found to persist for 6-8 weeks during spring and autumn and for more than three months in the winter. Recommendations for the use of herbicides have therefore to be very carefully framed. Where, however, methods have been recommended by the Station for specific crops these may be followed with complete confidence. This applies, for example, to the specialised and valuable asparagus growing industry of some 1,500 acres in which results have been particularly successful. Weed troubles have also been reduced in the 47,000 acres of scarlet runner, broad and French beans grown in England and Wales by making use of the Station's findings. Success is now being achieved with weed control in peas, carrots, parsnips and parsley.

The Section also studies cultural methods of weed control and is at present interested in the effects of cultivation and cropping on the numbers of viable weed seeds in the soils of commercial holdings with long histories of vegetable growing. Experiments started on corn land revealed initial populations of 230 million viable seeds per acre. Clean cultivation maintained a constant halving of the population each year irrespective of the depth of ploughing employed, but shallow rotavation was only half as effective as ploughing after six years treatment. Annual applications of farmyard manure have not affected either the number or the species of weeds found in these soils.

STATISTICS

This section plays a vital part in many of the field experiments involving the combined efforts of two or three sections concerned with different scientific disciplines. It affords invaluable service in giving advice in the design of experiments and by assistance with the analysis of results of complex experiments involving large amounts of data ; the section is also able to assist with problems requiring the advice of a trained mathematician.

In addition to service duties the section has a research programme of its own and is particularly interested in the study of plant density, and in growth analysis techniques which enable more information to be extracted from experiments with growing plants.

It is hoped that the scope of the section's own research interests, as well as those of the other sections, will be increased when the Orion computer is installed at the Rothamsted Experimental Station and ancillary equipment at Wellesbourne makes it possible to send programmed data to a central computing service.

SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

The Scottish Horticultural Research Institute is one of the group of eight institutes financed by the Department of Agriculture and Fisheries for Scotland with the scientific advice of the Agricultural Research Council. It is one of the younger members of the group and owes its existence to a recommendation of a committee set up in 1944 to review the research needs of the horticultural industry in Great Britain and consider what extensions might be desirable after the war. The recommendation that new research centres should be set up in Scotland initiated several years of planning, which culminated in the formal incorporation of the Institute in 1953, with a Governing Body appointed by the Secretary of State for Scotland. The site at Mylnefield, Invergowrie, by Dundee, had been acquired in 1950, and Dr. T. Swarbrick appointed as Director in 1951. There were also at that time two small teams of scientists engaged in special researches on fruit in Scotland ; one known as the Scottish Raspberry Investigation, based at Dundee, and one at Auchincruive in Ayrshire called the Strawberry Disease Investigation. Both were absorbed into the new Institute, which thus began with a nucleus of experienced staff and a flying start in research in its allotted field. The group at Auchinruive, for good technical reasons, continued their work in the same place, forming what is now called the West of Scotland Unit of the Institute.

The Institute has been greatly helped, especially in its early days, by its academic neighbour, Queen's College, Dundee, with which it maintains close relations. Through this connection it is recognised by the University of St. Andrews as a centre for post-graduate studies, and several senior members of the staff hold appointments as honorary lecturers in the University.

Recent Developments and Outlook

When the Institute received its first Visiting Group, in 1955, some of its departments had not a great deal more to show than a programme. It had been on the Mylnefield site only two years, and for most of that time in temporary laboratories awaiting completion of the new building. Moreover, half the scientific and experimental staff of 21 were recent recruits. There was, nevertheless, good research going on in continuation of the established programme of the Raspberry and Strawberry Investigations, and several promising new investigations had been opened.

The Visiting Group of 1961 found the Institute firmly established and thriving. The number of scientific and experimental staff has increased to 32 and the number of assistants doubled. To accommodate the larger staff an extension to the laboratories had recently been completed and occupied. Above all, the research programme had developed strongly along the lines discussed and agreed six years earlier, and was producing results that justified the expansion. The present size and facilities of the Institute are still modest

in relation to the breadth of its interests and the scientific quality of its work. Some further growth is therefore to be expected, both to extend the advances already made and to allow the taking up of new problems, of which there is no scarcity.

The Research Programme

The Institute was conceived and established in recognition of the fact that commercial growers of fruit and vegetables in Scotland have special problems associated with Scottish conditions and circumstances. These are direct or indirect consequences of the northerly latitude, which imposes a seasonal variation of climate significantly different from that experienced in the southern districts of Britain. Differences in temperature ranges, in day length, and in winter light are sufficient to have marked effects on the relative performance of different crop plants. These factors are thus largely responsible for the nature of the horticultural crops grown in Scotland, and hence for the pattern of Scottish horticulture.

The primary function of the Institute is therefore to study Scottish horticultural problems in their proper context and to seek varieties, cultural methods, and plant protective techniques appropriate to Scottish requirements. The outlines of departmental programmes given in the following paragraphs show that all these objects are being pursued, not singly but in relation to each other. There is an emphasis on plant breeding in four departments which reflects the importance attached to producing new varieties of soft fruit and vegetables ; and these are required to be not only resistant to major diseases but also well adapted to northern conditions and to the special needs of the processing industries. There is good correlation between field comparisons of cultural methods and more abstruse studies in crop physiology designed to explain field behaviour. The plant pathologists have concentrated to good effect on the most important diseases of the raspberry and strawberry, paying due regard to the influences of variety and climate.

By its pattern of research, the Institute has shown again what has repeatedly been found elsewhere—that the investigation of local problems, if scientifically planned and carried through to fundamentals, produces results of much more than local value. Basic research at Mylnefield has already made some notable contributions to horticultural science and attracted international attention in the course of work planned to meet Scottish needs.

The development of the research programme has been traced in detail in the annual reports which the Institute has issued since 1953. The position reached in 1961 is briefly as follows : —

Pomology The Pomology department gives most attention to soft fruits, especially raspberries, which are the most important fruit crop in Scotland. Long-term field experiments to compare cultural methods and define nutritional requirements are developments of studies begun in 1946 by the Scottish Raspberry Investigation. An extensive raspberry breeding programme has been added. The department is also breeding black currants, and collaborates with the West of Scotland Unit in testing new varieties of strawberries.

An aspect of soft fruit culture receiving special attention is the use of chemical methods for weed control. The weed-killing power of new herbicides can be evaluated by relatively simple practical trials ; but the increasing

use of these chemicals is raising more difficult questions, relating to their persistence in the soil and to the long-term effects of repeated applications, which also have to be answered.

The top fruits are not neglected. Some of the first trials planted at Mylnefield were variety and rootstock trials of apples, to discover the varieties and combinations best suited to Scottish conditions. These are now old enough to give useful information. Similar trials have been started with plums.

Vegetable Crops. This department started in 1953 with a wide field of possible studies in which it has to be carefully selective. Emphasis has been laid on finding or developing varieties of vegetables better suited to the Scottish climate and markets than those in general use. The major projects are therefore in plant breeding, though to obtain necessary information the department also studies cultural methods and in some instances the developmental physiology of its crops. The policy has been to start, for each species on the programme, with a survey of a wide range of British and foreign material ; and to initiate breeding only when satisfactory varieties cannot be found. Variety trials still constitute a substantial part of the work: in 1961, varieties of nine different species of vegetables were under observation. Breeding started quite early with Brussels sprouts, winter cabbage and French beans, and is well advanced in all those crops. Carrots have been added recently. The breeding programmes take full account of the requirements of the canners and freezers, who are the biggest buyers of vegetables in the region round Dundee.

Plant Physiology. The department of Physiology has concentrated on the growth and development of the strawberry plant, and particularly on the relations between environment and the production of hormone-like substances that regulate vegetative growth and flowering. The strawberry has proved to be a convenient experimental plant, and the analysis of its behaviour in response to various combinations of temperature and day-length, to nitrogen nutrition, and to applied growth-regulating substances such as gibberellic acid, is of considerable scientific interest. The department is relating its results to field practice and showing that they are also of great practical significance. The removal of the foliage of strawberry plants after harvest has a remarkable effect in increasing fruit yields in some circumstances. The physiological findings explain why this should be, and indicate the conditions under which the effect is to be expected. Another practical application of physiological findings is in the cold storage of runner-plants to provide material for the early planting that has been found desirable.

Genetics. The Genetics department was set up to support the practical breeding programmes with fruit and vegetables, which are being followed in other departments of the Institute, by investigating some of the more fundamental genetical problems that they meet in the course of their work. One of its first tasks was to study the disorder in strawberries known as " June Yellows ", which had led to breakdown in the variety Auchincruive Climax and was believed to be due to genetic causes. The research confirmed the genetic origin of the trouble and was useful in showing how to reduce the risk of its recurrence in new varieties. Five years' work, however, indicated little hope that June Yellows could be bred out of existing varieties that suffer from it, and the study has therefore been discontinued. Attention is now being given

to the production and cytogenetical study of species—hybrids in the genus *Ribes*—with a view to extending the Institute's breeding programme with black currants.

The department has its own breeding programmes, particularly with blackberries and their relatives which present special problems in the genetical mechanisms involved. It is also studying variation in glasshouse tomato varieties grown in Scotland and breeding new varieties adapted to Scottish conditions.

Virology. The work of the Virology department has been a direct continuation of research on the virus diseases of raspberries begun by the Scottish Raspberry Investigation a decade before the establishment of the Institute. It has expanded to include work on the virus diseases of other crops of importance in Scotland, including strawberries and potatoes ; but circumstances have dictated a concentration of effort during the last few years along one line of investigation which has been outstandingly rewarding.

By 1955, the researches of Dr. C. H. Cadman on the serious leaf-curl disease of raspberry in Scotland had suggested that it was due to a virus transmitted in some way through the soil. The suggestion was closely followed up, because at that time soil-borne viruses (though they had been reported from other countries) were generally regarded as uncommon and relatively unimportant. In the next five years the whole picture changed. Discoveries at Mylnefield coincided with others made abroad, especially in U.S.A., and it is now known that leaf-curl of raspberry in Scotland is only one of the group of virus diseases transmitted through the soil by eelworms and infecting a wide range of plants including strawberry, potato and many other crops. The major contribution made by Dr. Cadman and his team to this notable advance in plant pathology was recognized by the holding of an international symposium on soil-borne viruses at Mylnefield in 1960, which was attended by research workers from Britain, Europe, Japan and the United States.

Research on soil-borne viruses is developing in two directions. The properties of the viruses themselves are being studied by serological techniques and by electron microscopy: and the identification of certain nematodes as the vectors is being followed by studies of their distribution and ecology which are essential for undertanding of the spread of the diseases and methods of control. At the same time there are many pressing questions still to be answered about the longer-known aphid-borne viruses of raspberry and strawberry, and their vectors. These are not being neglected. The department's programme therefore includes entomological as well as virological and nematological researches. It can only select a few from many interesting problems awaiting solution, and in its selection is careful to maintain a balance between work to meet immediate practical needs in disease control and the more basic research that is building up knowledge for use in the future.

Mycology. Though virus diseases are of outstanding importance in Scottish horticulture, they are not the only pathological problems needing study. The mycology department is concerned with plant diseases due to fungi, and has concentrated most of its effort on the grey moulds caused by

Botrytis. These are specially important in Scotland on raspberries, strawberries and tomatoes, which have therefore received most attention. The researches cover all aspects of the disease—the biology of the fungus, the conditions governing sporulation, spore release, dispersal, germination and infection and methods of control, including not only the use of fungicides but also control by modifications of growing conditions and observations on the relative susceptibility of crop varieties.

West of Scotland Unit. The Institute's West of Scotland Unit, situated at Auchincruive in Ayrshire, is engaged in a programme of strawberry breeding which was initiated by the officer in charge, Mr. R. D. Reid, thirty years ago. The object then, as now, was to produce varieties resistant to a disease which devastated the Lanarkshire strawberry industry in the nineteen-twenties and later became known elsewhere as Red Core. This disease is an example of a class of problems, not uncommon in agriculture, that may never be "solved" in the sense that research on them will be no longer necessary, though continuous research may be highly successful and profitable from the growers' point of view.

Red Core is caused by *Phytophthora fragariae*, a fungus nearly related to that causing potato blight and sharing the same ability to give rise to new so-called " physiologic races " capable of attacking plants that have been bred for resistance to known races. The variability in the pathogen is the reason why breeding for resistance has so far succeeded only in " keeping one jump ahead of the parasite ", and must be continued. New knowledge, which the Unit is seeking, may alter the outlook. Meanwhile the tactics adopted have proved very profitable. Auchincruive varieties have been widely grown and esteemed for their combination of disease resistance with other characters desirable in commercial strawberries. It was unfortunate that Auchincruive Climax broke down, on account of an unforeseeable genetic defect, when well on its way to becoming the most popular strawberry variety in Britain ; but Climax was replaced by Talisman and Redgauntlet and there is promise of still better varieties to come.

The work has been kept at Auchincruive because it depends on the use of infected soil for field tests of resistance, but it is otherwise integrated with the programme at Mylnefield. Parallel with the breeding, the Unit, since it became part of the Institute, has been making comprehensive studies of the *Phytophthora* and its numerous races, and of the inheritance of resistance or immunity in strawberry varieties and related species of *Fragaria* ; thus accumulating information to guide the breeding programme.

THE WORK OF THE COUNCIL'S UNITS

The Council has set up a number of Units, almost all of which are closely associated with universities. Normally the object in setting up a Unit is to provide a distinguished university scientist, who has established a reputation in a field of science of potential interest to the Council, with greater opportunity to develop his researches than would otherwise be possible. The director of a Unit in a university is normally a professor or reader and usually serves in an honorary capacity. He has full freedom to plan his research programme and no attempt is made to subject it to the oversight or direction that is applied to the work of the institutes.

In this report brief summaries are given of the work of two of the Council's Units ; subsequent reports will include reviews of the work of the remaining Units.

UNIT OF EXPERIMENTAL AGRONOMY

The genesis of this Unit stemmed from developments which started early in the Second World War, when shortages of manpower emphasised the need to substitute chemical methods of weed control for hand weeding, and shortages of shipping posed the question whether some of the foodstuffs, such as oilseeds, normally imported in peacetime could be grown at home. By the end of the war, the development of new techniques and the appraisal of novel compounds of exceptional potency* had gone far enough to show that their introduction would radically affect agricultural practices at home and abroad. It was also apparent that it would be many years before the flow of imported foodstuffs would return to normal and that a further assessment of linseed and similar crops would be warranted.

During the course of these two types of investigation a team of considerable size was built up and when the leader (G. E. Blackman) was appointed in 1945 to the Chair of Rural Economy at Oxford, the Agricultural Research Council negotiated with the University for members of the team to continue their work at the Department of Agriculture. This arrangement continued until 1950, when it was decided that these researches should be put on a more permanent basis and the Unit of Experimental Agronomy came into being. Since the establishment of the Unit, a contribution to the cost of the work has been made from Colonial Delevopment and Welfare Funds (now administered by the Department of Technical Co-operation).

During the war the main aim in the investigations concerned with weed eradication was to develop and perfect techniques capable of being transferred directly to farm practice. Therefore most of the research consisted of field trials ; the approach was often empirical and leads had to be followed up without a proper understanding of the underlying causes. With the move to Oxford there was a reorientation of the programme: the field trials were continued but were supplemented by studies of the nature of herbicidal action and of the factors determining selectivity. At the outset it was self-evident that it would be quite impracticable to tackle simultaneously all the facets of herbicidal action and that to maintain the advance over a wide front there would need to be a frequent change of emphasis. Even within these restricted aims it was also appreciated that the researches were likely to reveal problems faster than they would be solved and that the reinforcement of the researches of the Unit by postgraduate students undertaking selected problems would be of great value. It was quickly found that this new field excited the interest of students coming to the Department and, in summarising the researches over the last twelve years, it is not possible to separate the researches within the Unit from those within the Department.

* The discovery and development of the "hormone" group of herbicides and the parts played by the three groups of workers involved was reported in Nature, 1945, volume 55, p. 497-501.

The earlier field experiments had already demonstrated that the destruction of susceptible species could be brought about by the application per acre of ounces rather than pounds of the most potent herbicides. Therefore the quantities involved in the death of individual plants were so small that special techniques would be needed for quantitative assays in laboratory investigations. The incorporation of radioactive isotopes into the compounds under examination seemed to be the most promising approach, especially since within the Department of Agriculture much attention was being given to the application of isotopic techniques to biological research. Experience soon showed that such techniques were invaluable for studying many of the physiological and biochemical effects and, over the years, much expertise has been accumulated in methods of synthesis, and in methods of estimating the isotopically labelled compounds or their products within the tissues.

In practice many herbicides are applied by spraying machines after the crop and the weeds have emerged above the ground. Under these "post-emergence" conditions the factors which, alone or in combination, operate to bring about selective destruction are differences between species in (a) the amount of spraying solution retained by the shoots, (b) the amount of the compound penetrating into the shoots, (c) the extent of the movement within the plants, (d) the degree of localised accumulation and (e) the physiological action at cell level. When the canopy is dense most of the spray droplets are caught by the foliage, and differential uptake through the roots of the small quantities of compound reaching the soil is usually of little significance compared with entry through the shoot. On the other hand, if the herbicide is incorporated in the soil before the crop is sown, or applied to the soil between sowing and the emergence of the crop, the primary components of selective action will include differential uptake by the roots. For the control of aquatic weeds entry may be both through the roots and the shoot.

A quantitative assessment of the retention factor established that for aqueous solutions the amount retained is dependent, on the one hand, on the number of drops applied per unit surface, their mean size and the surface tension and, on the other, the degree of leafiness, the pattern of the leaf arrangement and the nature of the leaf surfaces. Using a range of annual species with contrasting habits of growth it has been demonstrated that, for a combination of many large drops and a high surface tension, there may be a ninefold difference between species in the degree of retention. In contrast, with fewer and smaller drops coupled with a low surface tension, the range of difference is narrowed to less than fourfold. It was further established that the amount retained changes with stage of development, primarily because of alterations in the degree of leafiness and characteristics of the leaf surface.

On the basis of these findings it is clear that differential retention is an important factor in determining the resistance or susceptibility of species. It is also possible to predict the conditions under which the level of retention will be maximal or minimal.

Considering next penetration, it is now well founded that the amount of herbicide penetrating into leaves is linked both with the environmental conditions and with the properties of the adhering aqueous solution. Penetration starts immediately and continues until a "dry" residue is left on the surface, when the rate of penetration falls abruptly. Therefore the amount

entering is linked with the time taken for "drying out", which in turn will depend on the climatic conditions. The period can be lengthened if it is possible either to select a compound which is highly soluble and hygroscopic or to add a hygroscopic agent.

Current research is concerned with a detailed analysis of the mechanism controlling penetration and, so far, most attention has been given to 2, 4-dichlorophenoxyacetic acid (2, 4-D). It is already evident that penetration into the lower surface of a leaf may greatly exceed penetration into the upper surface and that for the species so far examined the rates of entry differ markedly. Entry into either surface is temperature dependent, but this effect is small compared with that produced by increasing light intensity. This new and unexpected observation cannot, as yet, be accounted for in terms of existing knowledge.

Once penetration into the leaf surfaces has taken place the extent of the subsequent movement is dependent, firstly, on transport through the mesophyll tissues between the surface and the vascular strands and, secondly, on transport in the strands out of the leaf into the stem and root. For 2, 4-D and allied compounds the seed and mode of transport in relatively undifferentiated tissues are disparate from those in the vascular strands. For example, in segments of bean petiole the speed of the downward movement of 2, 4-D and 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5-T) is less than 1 mm. per hour, whereas within the vascular strand the rate is at least 100 times as great. In parenthesis it may be added that, when these two compounds are introduced into the lower part of the bean stem, the *upward* movement through the vascular bundles is again more than ten times faster than the downward movement from the leaf.

It is well established that, while some herbicides are freely transported from the leaves to the stem, others are not. The underlying causes of these differences in mobility are still being examined. So far it has been established for a series of substituted phenoxyacetic acids that the ability to move through segments of bean petioles is linked with the chemical structure. For many perennial weeds or woody species, a requirement for successful control through an application to the aerial parts is that enough of the compound is transported to the underground system. Field experiments on many perennial species have established that the timing of the application is often critical. Studies of transport within bracken have shown that the extent of downward movement of 2, 4-D is dependent on the stage of the development of the frond and that even when transport is maximal movement into the rhizomes is limited. Similar experiments on couch grass (*Agropyron repens*) with 2, 2-dichloropropionic acid have also shown that the extent of transport along the rhizomes is a primary factor in determining the degree of control.

From the results it can be concluded that the development of new and more potent herbicides for the eradication of perennial species will depend on the discovery of compounds which combine persistency in the tissues with greater mobility.

Soon after the war many of the Colonies became interested in the applications of new herbicidal techniques to their conditions or problems. In East Africa, in particular, it seemed that the selective eradication of woody species

in areas infested with tsetse flies would lead to their control, and members of the Unit paid a number of visits to help in initiating field trials. It was established that a number of compounds, including 2, 4, 5-T, could induce defoliation and the question arose whether an aerial application of a defoliant would so alter the micro-climate that the habitat would become untenable to the flies. Tests with the butylester of 2, 4, 5-T revealed that the reactions of the species in the communities were divergent ; some trees were killed, some were defoliated but other failed to shed their leaves. It was judged that such a technique would not be practicable unless a more complete and prolonged defoliation could be achieved and research was started at Oxford on the physiological factors regulating abscission. For a range of deciduous species it was confirmed that premature abscission could be induced provided that the timing and the dose to the leaf were carefully controlled. It therefore seemed necessary to repeat such experiments under tropical conditions and here it was discovered that only in some of the evergreen species examined was defoliation accelerated. Subsequently studies at Oxford showed that, according to species, 2, 4, 5-T could either accelerate or retard the ageing of the leaf tissue. A further analysis has demonstrated that when localised applications of some synthetic auxins are made to the leaves of deciduous species the loss of chlorophyll is arrested and protein synthesis is maintained at a high level. This research is being continued since it may well throw light on the mode of action at cell level.

One other example of collaborative research will be cited. In 1951 it was announced that if 2, 4-D is applied to the scraped bark below the tapping panel of a mature rubber tree the yield of latex is subsequently increased for several months. By 1955 workers at the Rubber Research Institute of Malaya had shown that 2, 4, 5-T was more effective. In 1956 a joint programme was initiated by the Institute and the Unit to make a systematic study of the relationship between chemical structure and the power to increase the yield of latex, since on the basis of the information accumulated by the Unit it seemed that the potency might be predicted. By 1960 it was established that a new compound synthesised by the Unit, 2, 4,-dichloro-5-flouro-phenoxy-acetic acid, was the most effective. A further series of experiments is now in progress.

Only brief mention will be made of the studies of the mechanisms of uptake since these have largely been carried out within the Department. It is apparent that the pattern and level of uptake are dependent both on the compound and on the species and that such differences can be correlated with variations in susceptibility in the field.

Although the main interests have centred round herbicides and herbicidal action, the Unit has continued to examine the possibilities of introducing new crops and the better exploitation of uncommon ones. When the research team was first transferred to Oxford, linseed seemed to be the most productive of the oil seed crops examined during the war. Further large-scale trials revealed that, because of the humid conditions at maturity, there are considerable difficulties in harvesting.

Attention was next turned to spring and autumn sown oil-seed rapes. Here there was a need to start from scratch and to examine all aspects of husbandry and harvesting. The trials showed that the autumn sown types

were the most productive and that the yields of the most suitable varieties were equal to those obtained in other European countries. Today autumn sown rapes are established crops on many farms. The factors limiting a further increase in acreage are threefold: damage from pigeons during the winter, the restricted demand for rape oil in Great Britain and the existing depression in world prices as a result of the great expansion of rape cultivation in Canada.

Another crop which is being studied is the opium poppy where both the seed and the morphine in the capsules are of economic importance. The first objectives were to make a world-wide collection of varieties and to perfect techniques of cultivation and harvesting. The initial variety trials established that there were a number of European varieties which could give high yields of seed but contained little morphine in the ripe capsules. The husbandry trials proved that there were no major difficulties in cultivating the crop on light soils and that combine harvesters could be modified to collect both the seed and the capsule. The main drawbacks were the low morphine content and the risk of much of the morphine being washed out of the ripe capsules by heavy rain. A breeding programme was therefore started both to raise the morphine content and to reduce the risk of loss. To date it has been established that the morphine content can be substantially augmented, and that by selection for the thicker capsule losses can be minimised, but it has not as yet been possible to combine these characteristics with a high seed yield. In the meantime a limited acreage is grown for seed each year in East Anglia.

In the United States the development of double-cross hybrids revolutionized maize as a crop and by the end of the war exploratory trials with some of the earliest American hybrids had already been undertaken in England by the original team. Later, with the setting up of a co-operative breeding programme between western European countries, a much wider selection of material became available to all participants, which included the Unit. Further trials demonstrated that a number of late maturing hybrids, especially suitable for silage production, are capable of producing very high yields of dry matter. Before the introduction of flail type forage harvesters the cutting and handling of the crop presented problems. For optimal production the plant population should be high and the distance between the rows narrow, but this restricts inter-row cultivation for the control of weeds. This draw-back is not, however, important since a number of herbicides are proving to be highly effective. The combination of high yielding hybrids with effective means of weed control and harvesting has led to a considerable acreage being sown in the last two years.

UNIT OF INSECT PHYSIOLOGY

The Unit of Insect Physiology continues to be occupied with studies on the basic physiology of insects ; but the selection of topics is influenced by the needs of agricultural entomology, particularly in fields likely to prove of direct or indirect value in the control of insect pests.

The properties of the insect cuticle and eggshell were early selected for detailed study because they determine both the survival of the insect in the dry terrestrial environment in which it lives and the penetration of insecticides. The study of the waterproofing waxes of the insect cuticle, which started when

the Unit was established in 1943, has recently yielded results which may prove of importance in biology in general. Information has been obtained about the molecular mechanisms on which the extreme waterproofing of the insect cuticle is based and about the transport of water and ions across the cuticular membrane.

New methods of section cutting and staining have been devised which form a useful connecting link between the light microscope and the electron mircoscope. These methods have been used to reinvestigate the histology of the insect nervous system which, in turn, has provided a background for the study of nutrition, metabolism and ionic exchange in the ganglia and nerves. This work is a contribution to the study of insect resistance to insecticides, a subject which has suffered from our almost complete ignorance about the cytology and permeability properties of the ganglia and their sheaths.

Continuing studies on insect hormones have been concerned, among other matters, with the action of farnesol and its derivatives which will reproduce all the effects of the juvenile hormone in preventing metamorphosis.

Various aspects of the physiology of aphids continue to occupy members of the Unit, notably the detailed analysis of the environmental and endogenous factors which control cyclical changes in form in aphids, and the physiological bases of migratory activity and host selection. The Cabbage White Butterfly, a useful insect for work with systematic insecticides but difficult to rear in captivity, has been bred continuously in the laboratory for about twelve years ; its biology and behaviour under conditions of culture have been investigated in detail and the nature of the resistance to a granulosis virus which has been acquired by this strain is under study. The virus is a potentially useful control agent and its properties and its relationship with the host are being investigated.

The section of the Unit stationed at King's College, Newcastle-upon-Tyne, is concerned mainly with the study of the fluctuations of population among insects in the field, notably in the Garden Chafer, leatherjackets, and slugs of agricultural importance. These researches have required also some physiological studies in the laboratory and have led to publications on the theory of natural control in populations. The work has two aims. Firstly, to meet some of the practical needs of advisory entomologists by providing knowledge of the biology and ecology of these pests, together with improved methods of field-sampling and laboratory culture ; and secondly, to further understanding of the spatial distribution and fluctuation of pest populations to discover why an organism is a pest only in certain places or in certain years.

There is a strong suggestion the number of *Tipula paludosa*, economically the most important species of leatherjacket, are greatly influenced by the amount and incidence of rainfall in the autumn and investigations are being made to confirm this. Work on slug populations in semi-permanent pasture and arable land is proceeding and a simple method of extracting them from sample units has been evolved. Studies of effects of environment on slug populations include such factors as grazing, grass-cutting, cover provided by stones, weather, predation and parasitization.

More detailed notes on aspects of current investigations of the Unit are given below.

Histology (V. B. Wigglesworth). The fixation of tissues with osmium tetroxide and the visualization of the bound osmium with ethyl gallate, combined with a simple method devised for section cutting in the half to one micron range, have made possible the development of histological procedures which give appearances identical with those seen in low power electron microscope pictures of osmium fixed material. These methods have been used to describe in detail for the first time the relations between the neurones and the glial cells in the insect nervous system, the endings of peripheral nerves, the uptake of nutrients by the ganglia, the possible relation between the dictyosomes (Golgi bodies) and the secretion of axoplasm, and (in combination with electron microscopy) the fine structure of the Malpighian tubules and the insect egg-shell.

Metabolism and ionic exchanges in the nervous system (J. E. Treherne). Studies have been carried out on the metabolic process and exchanges of ions and molecules in the insect central nervous system. It has been shown that the exchanges of labelled sugars and various inorganic ions take place relatively rapidly between the haemolymph and the nervous tissues. Efflux experiments have demonstrated the presence of a rapidly exchanging ion fraction in the extracellular fluid of the cockroach abdominal nerve cord. The ionic composition of this fluid appears to be very different from that of the haemolymph, due to the presence of free anion groups which are possibly associated with mucopolysaccharide substances in the extracellular spaces. The excess of inorganic cations in the extracellular fluid is in accordance with a classical Donnan equilibrium with the haemolymph.

These results suggest that some of the well-known effects resulting from the desheathing of insect nerves may result from the disruption of the Donnan equilibrium with the haemolymph rather than to any significant properties of the nerve sheath as a diffusion barrier. Recent experiments on the effects of ions on the electrical activity of the cockroach nerve cord have confirmed that the enhanced rates of potassium depolarization in desheathed preparations partly resulted from the alteration of the sodium content of the extracellular fluid resulting from the desheathing procedure.

Electron microscope studies of the cockroach nervous system have also been carried out, in collaboration with Dr. D. S. Smith, in an attempt to relate some of the experimental findings to the fine structure and organisation of the central nervous system. In particular the structure of the extracellular system has been carefully examined in an attempt to determine the various routes involved in the mobilisation and movement of ions and molecules in the ganglia and connectives of this insect.

The waterproofing waxes of the insect cuticle (J. W. L. Beament). Following the original demonstration by Wigglesworth and Beament in 1945 of waterproofing waxes on insect cuticle, and some of their characteristics, little fundamental progress was made for a number of years, and their results were questioned by a number of authors. But new methods have now been devised by which evaporation from the insect can be measured with great accuracy under carefully controlled conditions.

The new equipment included an electronic thermostat of great accuracy and wider application than the specific purpose of controlling the temperature of air in a small enclosure. As a result, the sudden discontinuity in transpiration through the cuticle at a specific temperature, so long disputed, was amply verified, and information on a wide range of insects obtained.

Following this, much has been discovered about the molecular mechanisms on which the extreme waterproofing of the insect cuticle is based. These ideas have been found also to explain the basis for permanently hydrofuge areas on the surface of aquatic insects, which are the essential physical feature of their respiratory exchange, and, perhaps, the mechanism whereby the tracheal system of all insects becomes filled with air at each moult. It is possible that these ideas have implications for the evolution of the insects.

In the latest phase of this work it has been found that the polar greases which make up the waterproof barrier carry a strong electrical dipole ; this shows itself as a permanent electrostatic charge across the cuticle. As a result of this, the dead cuticular membrane of an insect such as the cockroach has been experimentally demonstrated to be capable of promoting the transport of both water and ions, and may lead us to a deeper understanding of these phenomena which are of fundamental importance in the mechanism of the living cell and its membranes.

The juvenile hormone (V. B. Wigglesworth). It was found by P. Schmialek in West Berlin, using the methods of assay developed by the Unit, that the material from various sources which will reproduce the effects of the juvenile hormone of insects is a mixture of farnesol and farnesal. Through close collaboration with Dr. Schmialek it has been found possible to test the biological properties of these and related substances. It has been shown that with the most effective substances adult characters can be suppressed and extra stages with completely larval characters can be produced by doses of less than 20 micrograms per gm. of body weight. This is of the same order as the amount of purified growth hormones required by vertebrates. The materials are effective also in inducing yolk formation in the eggs of adult females deprived of corpus allatum.

Aphid polymorphism (A. D. Lees). Aphids have an almost bewildering variety of forms, many species possessing several kinds of parthenogenetic females in addition to sexual egg-laying females and males. Although this polymorphism is known to be effected by the environment, the general picture has been confused.

Studies of the vetch and bean aphid *Megoura* have shown that embryos developing in the abdomen of viviparous parents can develop along a number of alternative developmental routes and that the choice of route is decided by certain definite environmental components which act through different maternal switching mechanisms. For example, the sex ratio of the parthenogenetic eggs is influenced by the ambient temperature ; the differentiation of half-grown embryos as parthenogenetic individuals or as egg-laying oviparae is dictated by the length of day and the temperature at which the mother develops. Finally, the growth of large embryos into winged or apterous individuals depends to a large extent on whether the mother lives out her life in comparative isolation or is jostled by other aphids. " Recognition " of one aphid by another is geared to the pattern of tactile stimulation received.

The mode of action of day length has been examined in detail. Photoperiodic receptors have never been identified in animals. Towards this end methods have been devised for illuminating very small areas of the insect for the duration of the required photoperiod. The region of greatest sensitivity proved not to be the compound eyes but a featureless area of cuticle on the dorsum of the head. The absence of specific cuticular sense organs suggested that the receptors may lie in the underlying brain tissue and may perhaps be neuroendocrine in nature.

The response to environmental factors is further influenced by certain " interval timers " which temporarily modify the maternal switching mechanisms so that one or more of the available developmental pathways is eliminated. For example, one timer of this kind is responsible for the inability of young clones to produce sexual forms in short photoperiods. The most interesting feature of these non-repetitive " biological clocks " is that they measure out a time interval which often extends over many generations. Their information must therefore be transmitted through the egg.

Aphid behaviour (J. S. Kennedy). Field and laboratory work on aphid behaviour has shown that the quality of light that is most attractive to a flying bean aphid changes as flight proceeds. An overwhelming response to the short wave-length light from the sky takes the flier upwards at first, but the longer wave-length light reflected from plants gradually becomes more attractive and finally brings about alightment on some plant which may or may not be a host. Some evidence has been obtained that this behaviour may not in fact require the true colour vision which aphids have been said to possess.

Work with the cabbage aphid showed that the host plant is distinguished from other plants only when the insect's mouth parts actually penetrate the leaf surface. A non-host leaf (bean) can be made entirely acceptable to this aphid by infiltrating the leaf with a mustard oil glucoside, sinigrin, already known to be the specific feeding stimulus for other insects living on Crucifers.

Observation on winged aphids showed that their behaviour is conducive to very general dissemination of the plant viruses they can carry, but favours the spread of certain viruses more than others, by each aphid species according to its range of host plants. On this basis some predictions were made concerning the mutual adaptations between aphids and viruses, and a subsequent analysis of all the available information on aphids as virus vectors gave some support to these predictions as a lead for future work.

Biology of the Cabbage White Butterfly in culture ; resistance to a granulosis virus. (W. A. L. David). During the period under review work on the biology and behaviour of *Pieris brassicae* in a laboratory culture was completed. This insect had not previously been bred continuously in captivity and the work was undertaken because it has proved to be a very useful insect for work with systemic insecticides, and certain other laboratories which wished to rear it had experienced difficulties.

Most of the factors which are likely to have an influence on mating, feeding, oviposition, hatching of the eggs, duration of the larval period, diapause and diel rhythm of emergence of adults from the pupae have been investigated. As a result the conditions which must be met when establishing a culture are understood and the data obtained on the biology of the insect

are useful when planning experiments. One particularly interesting conclusion is that the adults become adapted to life in a cage. They cease to batter themselves against the walls and begin to feed on artificial flowers. This adaptation does not occur during the lifetime of one generation but is progressive and only reaches its maximum after three or four generations in captivity.

P. brassicae is subject to a granulosis virus disease and this is being investigated. It has been shown that the laboratory stock, which was heavily attacked in 1955, when there was a severe epizootic in the wild population, became resistant to the virus in comparison with newly caught wild stock. Further work is now being carried out in order to learn more about certain properties of the virus and to study its relationship with its host since it is potentially a useful control agent.

Population ecology of leatherjackets and slugs; population dynamics (A. Milne ; R. Laughlin ; A. South). *Leatherjackets.* There has been a steady if slow accretion of data on the comparative ecologies of the *Tipula oleracea* group despite the hampering of field work by several years of very low populations. Perhaps the most interesting point emerging from these data so far is a strong suggestion that numbers of *Tipula paludosa* (economically the most important species) are greatly influenced by the amount and incidence of rainfall in the autumn after the onset of ovidisposition. This suggestion was confirmed in autumn 1961 by a field experiment with artificial rainfall. The experiment was repeated in the autumn of 1962.

The development of an efficient culture method has allowed the laboratory side of the investigations to proceed more speedily. Eggs are incubated on wet filter paper in special containers. Larvae are kept in sand of a suitable dampness and are fed on dried powdered grass. Pupae are kept in holes in damp plaster of Paris blocks. Reared in this way, crane flies are healthy, considerably larger and (the females) more fecund than those collected in the field.

This culture method has made it possible to study the growth of larvae in the laboratory. Growth is exponential in the first three instars and linear in the fourth. Apart from that, the three species are very unlike in their growth patterns. *T. oleracea* grows continuously until 5-10 days before pupation when weight begins to fall. *T. czizeki* grows continuously up to the middle of the fourth instar (weeks before pupation) when a peak weight is reached and then maintained until a few days before pupation. *T. paludosa* is like *T. czizeki* with the addition of a weak diapause in the third instar ; a period of cold treatment is necessary to produce a normal third moult. These differences together with differences in life-cycle are of ecological significance. The culture method is also lending itself to an investigation of disease and parasitism in samples of larvae taken from the field.

Dessication rate of the egg has been studied in *T. oleracea.* Tests have also been carried out to determine the ability of the egg to survive desiccation. As it gets older it can survive longer periods of dessication. In fact it seems likely that, in nature, eggs of *T. oleracea* run less risk of death from desiccation than has been thought by previous authors.

Slugs. Research has now been going on for three years on questions raised by the National Agricultural Advisory Service. On the ecological side, the work is basically a study of the population of *Agriolimax reticulatus* in a semi-permanent pasture, with some observations on the associated species *Arion intermedius* and *A. circumscriptus.* Latterly, however, the investigation has extended to include, for comparison, the population of an arable field adjoining the pasture. A simple but efficient method of extracting slugs from sample units has been evolved, a method suitable for units of arable as well as pasture land. Life-cycles have been elucidated by regular sampling. Data on natural growth rate and feeding activity have been obtained by confining individuals in the field. Studies have been made of the effects of environment on population, particular attention being paid to grazing, grass-cutting, cover provided by stones, weather, predation and parasitization. In the laboratory, satisfactory culture methods have been devised. These have made it possible to investigate several biological matters under controlled conditions, e.g. growth rates at constant and at fluctuating temperatures, and feeding. The effects of dessication on slugs and their eggs have also been examined.

Population dynamics. Contributions have been made to the theory of natural control of insect populations, a matter about which there is much controversy ; and on the definition of " competition " among animals, about which there is much confusion.

ADMINISTRATION AND FINANCE
1961-62

Obituary

The Council records with regret the death of the following :

On 27th November, 1961, Professor F. G. Gregory, formerly Director, Research Institute of Plant Physiology.

On 1st February, 1962, Dr. Alex Muir, Head of Pedology Department, Rothamsted Experimental Station, and of the Soil Survey of England and Wales.

Honours and Awards

Her Majesty the Queen conferred the following honours :—

C.B.E.	Dr. J. W. Gregor, Director, Scottish Plant Breeding Station
	Dr. A. B. Stewart, Director, Macaulay Institute for Soil Research
O.B.E.	Dr. C. Horton-Smith, Houghton Poultry Research Station
	Mr. R. D. Reid, Scottish Horticultural Research Institute
M.B.E.	Mr. A. L. Leggett, Secretary, Agricultural and Horticultural Research Station, Long Ashton
	Mr. W. Middleton, lately Secretary, Rowett Research Institute.
B.E.M.	Mr. F. J. Seabrook, Rothamsted Experimental Station

Dr. P. H. Gregory, Dr. A. Kleczkowski and Dr. H. L. Penman, all of Rothamsted Experimental Station, were elected Fellows of the Royal Society.

Dr. R. Hull, Head of the Dunholme Field Station of Rothamsted Experimental Station, was awarded the Research Medal for 1961 of the Royal Agricultural Society of England.

Mr. A. R. Wannop, O.B.E., Director of the Hill Farming Research Organisation, received the George Hedley Award of the National Sheep Breeders' Association for outstanding service to the sheep industry.

Staff

At 31st March, 1962, there were 4,822 members of staff employed at the agricultural research institutes. Of this number 945 were in the Scientific Officer Class, 738 in the Experimental Officer Class and 989 in the Scientific Assistant Class. The remainder were mainly in the Executive, Clerical and Industrial Classes. The number of staff employed in the Council's Secretariat was 91.

Staff Changes

Dr. R. Markham, F.R.S., Director of the A.R.C. Virus Research Unit, was promoted to the grade of Deputy Chief Scientific Officer on 1st July, 1961.

Dr. C. G. Johnson was appointed Head of the Entomology Department at the Rothamsted Experimental Station on 1st October, 1961, in succession to Dr. K. Mellanby, who accepted an appointment with the Nature Conservancy.

Dr. D. J. Griffiths of the Welsh Plant Breeding Station was promoted to the grade of Senior Principal Scientific Officer and designated Deputy Director on

1st October, 1961, in succession to Mr. G. Evans, Assistant Director, who retired on 30th September, 1961.

Dr. D. A. Haig was appointed Head of the new Virology Department at the A.R.C. Institute for Research on Animal Diseases, Compton, on 1st November, 1961.

Dr. R. D. Keynes, F.R.S., Head of the Physiology Department at the A.R.C. Institute of Animal Physiology, was designated Deputy Director on 1st January, 1962.

Mr. G. G. Samuel, M.Sc., Scientific Adviser to the Secretary, retired from the Council's service on 31st March, 1962.

Overseas Liaison

By providing funds to enable scientific staff from the agricultural research institutes in the United Kingdom to visit research centres abroad and to attend many of the major scientific conferences throughout the world, the Council helped to facilitate the exchange of scientific information. Among the principal meetings in 1961–62 were the 5th International Congress of Biochemistry, Moscow, the 8th International Congress of Animal Production, Hamburg, the 4th International Congress of Animal Reproduction, Amsterdam, and the 18th International Congress of Pure and Applied Chemistry, Montreal. Two scientists from the agricultural research service also attended the joint I.A.E.A./F.A.O./W.H.O. Conference on the "Use of Radioisotopes in Animal Biology and the Medical Sciences", which was held in Mexico City.

A considerable number of scientific staff also went abroad under the auspices of various international organisations for the purposes of advising on local problems arising within their expert fields of interest as well as to acquaint themselves with the latest scientific techniques currently being used by their scientific colleagues in those countries. In addition, many hundreds of visitors from abroad were received by the agricultural research institutes. These included students who came under the auspices of the British Council and international agencies such as the Food and Agriculture Organization of the United Nations, the Colombo Plan and the International Atomic Energy Agency.

Under the agreement negotiated by the Soviet Relations Committee of the British Council with the U.S.S.R. State Committee for Cultural Relations with Foreign Countries for the interchange of scientists with the U.S.S.R., two research workers from the agricultural research service visited research centres in the U.S.S.R. and three Soviet specialists were received at research institutes in this country during the year under review.

Professor A. C. Frazer, a member of the Council, visited East Africa in September, 1961, as Chairman of a Commission appointed to advise on the most suitable structure for the management, direction and financing of agricultural research on an East African basis and on the future of the Tropical Pesticides Research Institute. Dr. E. G. Cox, Secretary of the Council, served as a member of this Commission.

Buildings and Property

Major schemes completed during the year included the installation of controlled environment chambers at the Plant Breeding Institute; the first phase of the erection of new buildings for the Macaulay Institute for Soil

Research* ; and the completion of new accommodation for the Scottish Station of the National Institute of Agricultural Engineering, which has moved from Howden to the Edinburgh Centre of Rural Economy at The Bush Estate*.

The major works in progress at the end of the year 1961–62 were : —

Animal Breeding Research Organisation : new headquarters building.

Animal Diseases Research Association, Moredun Institute : new microbiology laboratories and a sheep metabolism and isotope unit.*

East Malling Research Station : new greenhouses.

Glasshouse Crops Research Institute : new heating system for trial glasshouses, and a laboratory/glasshouse unit for plant pathology and entomology work.

Houghton Poultry Research Station : facilities for research on diseases of the leucosis complex.

Institute of Animal Physiology : pig research laboratory.

Macaulay Institute for Soil Research : new Institute buildings (second phase).*

National Institute for Research in Dairying : cowshed and milking parlour ; facilities for " germ free " research ; facilities for research on pig metabolism and baby pig nutrition ; small animal house.

Radiobiological Laboratory : new laboratories.

Research Institute (Animal Virus Diseases) : building for the production of vaccine on a commercial scale ; re-building of main isolation compound ; improved disease-security measures.

Rothamsted Experimental Station : additional building for Statistics Department ; West Building extension.

Weed Research Organisation : development of site at Begbroke Hill Farm, Oxford, including laboratories and farm buildings.

Welsh Plant Breeding Station : new laboratory building for research on developmental genetics.

Among the projects in various stages of planning were : —

Institute of Animal Physiology : new laboratories for the Pathology and Physiology departments.

Meat Research Institute : buildings for new institute at Langford, near Bristol.

National Institute of Agricultural Engineering : new buildings for the Harvesting and Handling department.

National Institute for Research in Dairying : new laboratory wing ; experimental calfhouse.

National Vegetable Research Station : provision of controlled-environment facilities.

Pest Infestation Laboratory : new laboratory block and canteen.

Rothamsted Experimental Station : glasshouses for the Nematology, Mycology and Insecticides departments.

Rowett Research Institute : new special services building and extension to experimental piggery*.

Virus Research Unit : laboratory extension and new glasshouses.

* Scheme financed by the Department of Agriculture and Fisheries for Scotland.

Land Agency Service

The Council's Land Agents, Messrs. W. H. Cooke and Arkwright, have continued to assist the Council in dealing with the many and varied problems of land and estate management that arise at the grant-aided institutes in England and Wales and at the Council's own establishments.

Agricultural Research Fund

The greater part of the Council's expenditure is met from the Agricultural Research Fund which is financed by a Parliamentary grant-in-aid. In the financial year ended 31st March, 1962, gross current expenditure was £5,671,228 ; capital expenditure on buildings and special apparatus amounted to £785,042. A grant-in-aid of £6,076,000 was voted by Parliament, of which £6,070,000 was drawn. The grant-in-aid was augmented by receipts totalling £289,289 derived mainly from sales of livestock, produce, etc., at research institutes and units and from rents and hostel charges as well as by contributions totalling £109,701 from Government Departments and other sources. These contributions included, *inter alia,* £14,537 from the Hops Marketing Board and the Institute of Brewing towards the cost of research on hops at Wye College ; £10,000 from the Animal Health Trust towards the maintenance of the Houghton Poultry Research Station ; £17,862 from the Department of Technical Co-operation towards the cost of the Council's Unit of Experimental Agronomy and the maintenance of the Tropical Liaison Department of the Pest Infestation Laboratory ; £54,389 from the United States Department of Agriculture under U.S. Public Law 480 in respect of agricultural utilisation research projects at the Low Temperature Research Station, the Institute for Research on Animal Diseases, Compton, and the Ditton Laboratory ; and £4,286 from the World Health Organisation towards the work of the Pest Infestation Laboratory.

The allocation under main heads of the gross expenditure from the Agricultural Research Fund was as follows:—

	£	*Percentage of total*
Administration (including grants for visits overseas)	206,513	3·2
Research institutes and units of the Council:		
Current expenditure	1,912,660	29·6
Capital expenditure	313,618	4·9
Grants to independent research institutes (England and Wales):		
for current expenditure	3,338,461	51·7
for capital expenditure	471,424	7·3
Special research grants	148,960	2·3
Grants to Universities for Special Equipment ..	13,479	0·2
Studentships, training awards and fellowships ..	27,558	0·4
Grants for Experimental Farm Buildings ..	23,597	0·4
	£6,456,270	100·0

Grants made from the Vote of the Department of Agriculture and Fisheries for Scotland

Grants to the independent agricultural research institutes in Scotland are made from the Vote of the Department of Agriculture and Fisheries for Scotland, on the advice of the Council. For the financial year which ended on 31st March, 1962, the total of such grants was £1,035,184 for current expenditure and £300,928 for capital expenditure.

Benefactions

By the terms of its Charter, the Council is empowered to accept and administer private funds or properties which may be given or bequeathed to it in trust, either for the general purpose of its work or for special objects within its field.

(a) *The Underwood Fund*

This fund has continued to be used by the Council to provide fellowships or grants for distinguished overseas scientists who wish to visit this country and who are likely, directly or indirectly, to assist the Council's work. The Council is willing to consider applications by, or on behalf of, such scientists, at any time of the year.

The income from the fund during the year ended 31st March, 1962, amounted to £5,519.

Recipients of grants made from the fund during 1961–62 included the following:

Professor S. Lepkovsky, of the Department of Poultry Husbandry, Berkeley, California, who spent five months at the Council's Poultry Research Centre ; Professor X. Aubert, Professor of Physiology, University of Louvain, who spent three weeks at the Council's Institute of Animal Physiology ; Professor R. H. Hageman, University of Illinois, during his stay at Long Ashton Research Station ; Dr. N. G. Baptist, Department of Biochemistry, University of Ceylon, who spent a year at the Rowett Research Institute ; and Dr. H. Koprowski, Director of the Wistar Institute, Philadelphia, who visited this country for a period of three weeks to undertake an appraisal of research in progress on scrapie disease.

(b) *The Wain Fund*

The objects of this fund, which was established in 1958, are to facilitate the interchange of scientists between universities in the United Kingdom and overseas and to further other schemes of benefit to agricultural research for which the ordinary funds of the Council are not available.

The income from the fund during the year ended 31st March, 1962, amounted to £3,919.

A grant from the fund was made during the year to Dr. L. Fowden, of the Department of Botany, University College, London, towards the expenses of visits to certain research centres in the U.S.A.

Financial Assistance from Outside Bodies

The Council gratefully acknowledges the assistance received during the year from the following:—

(1) *W. K. Kellogg Foundation*

Two fellowships were awarded to members of the agricultural research service nominated by the Council.

(2) *Hatley Foundation*

An allocation of $3,400 was placed at the disposal of the Council by the Foundation ; six grants were made to enable research workers to visit centres in North America.

(3) *Rockefeller Foundation*

Dr. R. S. Pitcher of East Malling Research Station was awarded a grant of £983 to enable him to visit the U.S.A. for discussions with American nematologists and to attend a symposium organised by the American Phytopathological Society.

(4) *Wellcome Trust*

The Trust made a grant of £10,500 to the Rowett Research Institute for the purchase of special radiographic equipment.

Dr. J. S. Tindal of the National Institute for Research in Dairying was awarded a Sir Harry Wellcome Travelling Fellowship to enable him to spend a year in the Anatomy Department of the University of California in Los Angeles.

(5) *British Egg Marketing Board*

The Board made a grant of £1,200 to Houghton Poultry Research Station for the purchase of a photomicroscope in connection with work on the immunology of coccidiosis.

(6) *Pig Industry Development Authority*

A grant of £1,620 p.a. for three years was made by the Authority to the National Institute for Research in Dairying for work on cervical mucus in the sow and £2,230 was granted to the Rowett Research Institute for investigations into " slight of lean ".

(7) *Animal Health Trust*

In addition to their normal annual contribution of £10,000 towards the running expenses of the Houghton Poultry Research Station the Trust made a grant for the construction of a self-recording experimental incubator for research on hatchability.

(8) *National Chemical Products Limited*

A grant of £250 was made by National Chemical Products Limited to the National Institute for Research in Dairying for work on the feeding of volatile fatty acids to ruminants.

(9) *Muscular Dystrophy Associations of America*

The Associations made a grant of £2,500 to the Institute of Animal Physiology for work on the effects of potassium and magnesium on the nervous system.

(10) *Sugar Research Foundation, Inc. of New York*

The Foundation made a grant of £2,000 to the National Institute for Research in Dairying for the first year of a three-year period for studies of the significance of dietary sugar in relation to the growth, fattening and milk production of ruminants.

(11) *International Atomic Energy Agency*

A grant of £5,550 was made by the Agency to the National Institute for Research in Dairying for one year in the first instance for an investigation of the origin of milk fat.

(12) *United States Department of Health*

The Department made a research grant of £38,500, for five years from May, 1961, to the Virus Research Unit for an investigation of virus and neucleic acid structure.

The Department also made a grant of £29,325, to the National Institute for Research in Dairying, for five years from February, 1962, for studies of the rheology of blood in flow and coagulation.

(13) *United States Department of Agriculture*

On the closing down of the Ministry of Agriculture, Fisheries and Food Research Establishment, Aberdeen, the Department agreed to transfer from the Research Establishment to the Low Temperature Research Station a proportion (for the period April, 1961 to June, 1963) of the following research grants which had previously been made, under United States Public Law 480, from the counterpart funds available in the United Kingdom:—

Grant for research on the biochemical and physical changes occurring in meat fibres when dehydrated by accelerated freeze-drying (proportion transferred £22,546).

Grant for research on the chemical changes in carotenoid pigments during processing and storage of selected vegetables (proportion transferred £27,926).

(14) *The States of Guernsey*

A capital grant of £5,800 and a maintenance grant of £2,500 per annum for three years has been made to the Glasshouse Crops Research Institute by the States of Guernsey for work on tomato breeding.

NORTHUMBERLAND

Chairman of the Agricultural Research Council

E. G. COX

Secretary of the Council,

Cunard Building,

15, Regent Street,

London, S.W.1.

19*th March,* 1963.

APPENDIX I

COMMITTEES

(*As at* 31*st March*, 1962)

STANDING COMMITTEE ON RESEARCH AFFECTING ANIMALS

Professor P. B. Medawar, C.B.E., M.A., D.SC., F.L.S., F.R.S. (Chairman).
J. D. Alston, J.P.
H. R. Barnell, M.A., B.SC., PH.D.
Professor F. W. Rogers Brambell, B.A., D.SC., PH.D., F.R.S.
R. E. Glover, M.A., D.SC., F.R.C.V.S.
G. N. Gould, J.P., F.R.C.V.S.
F. H. K. Green, C.B.E., M.D., F.R.C.P.
Professor C. S. G. Grunsell, PH.D., M.R.C.V.S.
Professor J. W. Howie, M.D., F.R.C.P.(GLAS.), M.R.C.P.(LOND.)
Elwyn Jones, O.B.E., J.P.
Professor Sir Hans A. Krebs, M.A., M.D., D.SC., F.R.C.P., F.R.S.
Professor P. L. Krohn, B.A., B.M., B.CH.
T. R. R. Mann, C.B.E., M.D., SC.D., PH.D., F.R.S.
Professor K. Mather, C.B.E., D.SC., PH.D., F.R.S.
Professor C. L. Oakley, M.D., B.S., D.SC., F.R.S.
Sir John Ritchie, C.B., B.SC., D.V.SC., LL.D., F.R.C.V.S., D.V.S.M., F.R.S.E.
Professor C. H. Waddington, C.B.E., M.A., SC.D., D.ÈS.SC., F.R.S.
Professor W. L. Weipers, B.SC., F.R.C.V.S., D.V.S.M., F.R.S.E.
Professor E. G. White, D.SC., F.R.C.V.S.
Professor V. B. Wigglesworth, C.B.E., M.A., M.D., B.CHIR., F.R.S.

STANDING COMMITTEE ON RESEARCH AFFECTING PLANTS AND SOILS

Professor T. A. Bennet-Clark, M.A., PH.D., F.R.S. (Chairman).
Professor R. M. Barrer, SC.D., F.R.S.
Professor D. S. Hendrie, B.SC., N.D.A., N.D.D.
Professor D. Lewis, D.SC., F.R.S.
Sir David Lowe, C.B.E., F.R.S.E.
Professor K. Mather, C.B.E., D.SC., PH.D., F.R.S.
W. C. Moore, C.B.E., M.A.
Professor Alexander Robertson, M.A., B.SC., PH.D., LL.D., F.R.S.
Sir Harold Sanders, M.A., PH.D.
Professor P. T. Thomas, B.SC., PH.D.
Professor R. L. Wain, D.SC., PH.D., F.R.I.C., F.R.S.
Professor C. W. Wardlaw, D.SC., PH.D., F.R.S.E.
Professor V. B. Wigglesworth, C.B.E., M.A., M.D., B.CHIR., F.R.S.
Professor W. T. Williams, D.SC., PH.D., A.R.C.S., D.I.C.
F. Yates, C.B.E., SC.D., F.R.S.

SOIL SURVEY RESEARCH BOARD

Sir William G. Ogg, M.A., B.SC., PH.D., LL.D., F.R.S.E. (Chairman).
Professor R. M. Barrer, SC.D., F.R.S.
J. Macdonald, C.B.E., B.SC.(FOR.), F.R.S.E.
W. Morley Davies, M.A., B.SC., F.R.I.C.
G. H. Mitchell, D.SC., F.R.S., F.R.S.E.
J. B. E. Patterson, M.SC., F.R.I.C.
N. H. Pizer, M.SC., PH.D., F.R.I.C.
D. Rhind, O.B.E., B.SC., F.L.S.
A. M. Smith, D.SC., PH.D.
Professor L. Dudley Stamp, C.B.E., B.A., D.SC., D.LIT., LL.D.
A. B. Stewart, C.B.E., M.A., B.SC., PH.D., F.R.I.C., F.R.S.E.
C. J. Stubblefield, D.SC., F.R.S.
Professor T. Wallace, C.B.E., M.C., D.SC., F.R.I.C., V.M.H., F.R.S.
A. S. Watt, B.A., PH.D., F.R.S.
A. Woodburn.

FARM BUILDINGS RESEARCH COMMITTEE

Sir Walter Drummond, D.SC., M.INST.C.E., M.I.MECH.E. (Chairman).
W. H. Cashmore, C.B.E., B.A., N.D.A.
Professor M. McG. Cooper, B.AGR.SC., B.LITT.
S. W. Cheveley, O.B.E.
D. Grant, F.R.I.C.S.
W. O. Kinghorn, B.SC.
Miss I. O. H. Lepper
R. G. A. Lofthouse, F.L.A.S., F.R.I.C.S.
P. J. Macfarlan, B.SC., N.D.A., N.D.D.
R. S. Morton, A.R.I.B.A., A.M.T.P.I.
G. D. Nash, A.R.I.B.A.
H. J. Rathbone, O.B.E., F.L.A.S.
C. Robinson, F.R.I.C.S., A.A.I.
F. G. Sturrock, M.A., B.SC., N.D.A., N.D.D.
J. K. W. Slater, M.A., M.SC. (Member and Technical Secretary).

FARM BUILDINGS RESEARCH COMMITTEE SUB-COMMITTEE ON GRANTS

Sir Walter Drummond, D.SC., M.INST.C.E., M.I.MECH.E. (Chairman).
J. Ashton, M.A., M.S., B.LITT.
W. G. Benoy, A.R.I.B.A.
W. Biggar, M.C., B.SC.
J. F. Edgar.
H. E. G. Read, C.B.E., J.P., F.L.A.S.
D. W. B. Sainsbury, M.A., PH.D., M.R.C.V.S.
C. N. Harvey, M.A., Q.A.L.A.S. (Technical Secretary).

FARMING ACTIVITIES OF RESEARCH INSTITUTES

J. D. Alston, J.P. (Chairman).
R. E. Glover, M.A., D.SC., F.R.C.V.S.
Elwyn Jones, O.B.E., J.P.
Sir David Lowe, C.B.E., F.R.S.E.
F. Rayns, C.B.E., M.A., SC.D.
Sir Harold Sanders, M.A., PH.D.
F. Yates, C.B.E., SC.D., F.R.S.

FOOD RESEARCH COMMITTEE

Sir David Lowe, C.B.E., F.R.S.E. (Chairman).
H. R. Barnell, M.A., B.SC., PH.D.
Professor T. A. Bennet-Clark, M.A., PH.D., F.R.S.
Professor A. C. Frazer, C.B.E., M.D., B.S., D.SC., PH.D., F.R.C.P.
Professor Sir Hans A. Krebs, M.A., D.SC., F.R.C.P., F.R.S.
T. R. R. Mann, C.B.E., M.D., SC.D., PH.D., F.R.S.
Professor P. B. Medawar, C.B.E., M.A., D.SC., F.L.S., F.R.S.

RESEARCH COMMITTEE ON TOXIC CHEMICALS

Professor A. C. Frazer, C.B.E., M.D., B.S., D.SC., PH.D., F.R.C.P. (Chairman).
J. M. Barnes, M.B.
T. D. Lewis, D.SC., F.R.I.C.
J. T. Martin, D.SC., PH.D., F.R.I.C.
J. L. McGirr, B.S., M.R.C.V.S.
K. Mellanby, C.B.E., B.A., D.SC.
W. C. Moore, C.B.E., M.A.
C. Potter, D.SC., D.I.C.
Professor O. W. Richards, M.A., D.SC., F.R.S.
Sir Harold Sanders, M.A., PH.D.
I. Thomas, M.SC., PH.D.
J. Wallace, M.A.
D. W. Wright, M.A.

TECHNICAL COMMITTEES

ANIMALS

NUTRIENT REQUIREMENTS OF FARM LIVESTOCK

D. P. Cuthbertson, C.B.E., M.D., D.SC., LL.D., F.R.S.E. (Chairman).
Professor R. G. Baskett, O.B.E., M.SC., F.R.I.C.
A. W. Boyne, B.SC.
R. Braude, D.SC., PH.D.
A. Eden, M.A., PH.D., F.R.I.C., DIP. AGRIC.
S. K. Kon, D.SC., PH.D., F.R.I.C.
F. H. Moult, M.SC.
Professor Alex Robertson, M.A., B.SC., PH.D., M.R.C.V.S., F.R.I.C., F.R.S.E.
J. A. B. Smith, C.B.E., D.SC., PH.D., F.R.S.E.
D. B. Wallace, M.A.
J. L. Corbett, B.SC.(AGR.), M.AGR.SC. (Member and Technical Secretary).

PIG RESEARCH

Professor R. G. Baskett, O.B.E., M.SC., F.R.I.C. (Chairman).
H. R. Davidson, M.A., DIP.AGRIC.
H. P. Donald, D.SC., PH.D., F.R.S.E.
A. Eden, M.A., PH.D., F.R.I.C., DIP.AGRIC.
H. I. Field, M.SC., M.R.C.V.S.
E. G. Johnson.
Professor H. G. Lamont, O.B.E., D.SC., M.R.C.V.S.
Professor I. A. McK. Lucas, M.SC.
P. J. Macfarlan, B.SC., N.D.A., N.D.D.
Professor L. P. Pugh, C.B.E., M.A., B.SC., F.R.C.V.S.
Sir John Ritchie, C.B., B.SC., D.V.SC., LL.D., F.R.C.V.S., D.V.S.M., F.R.S.E.
Professor Alex Robertson, M.A., B.SC., PH.D., M.R.C.V.S., F.R.I.C., F.R.S.E.
K. L. Robinson, B.SC., B.AGR.
R. Braude, D.SC., PH.D. (Member and Technical Secretary).

POULTRY RESEARCH

Professor K. Mather, C.B.E., D.SC., PH.D., F.R.S. (Chairman).
R. Coles, B.A., D.SC., PH.D.
H. R. Finn.
S. K. Kon, D.SC., PH.D., F.R.I.C.
Sir John Ritchie, C.B., B.SC., D.V.SC., LL.D., F.R.C.V.S., D.V.S.M., F.R.S.E.
Alan Robertson, B.A., D.SC.
J. Sutton, M.B.E.
R. F. Gordon, D.SC., M.R.C.V.S. (Member and Technical Secretary).

SCRAPIE RESEARCH

R. E. Glover, M.A., D.SC., F.R.C.V.S. (Chairman).
E. A. Carmichael, C.B.E., M.B., F.R.C.P.
W. S. Gordon, C.B.E., PH.D., M.R.C.V.S., F.R.S.E.
E. Weston Hurst, M.D., D.SC., F.R.C.P.
R. A. Markham, M.A., PH.D., F.R.S.
Professor L. P. Pugh, C.B.E., M.A., B.SC., F.R.C.V.S.
Sir John Ritchie, C.B., B.SC., D.V.SC., LL.D., F.R.C.V.S., D.V.S.M., F.R.S.E.
E. T. C. Spooner, M.A., M.D.
Professor Lord Stamp, M.A., M.B., B.CHIR.
J. T. Stamp, D.SC., M.R.C.V.S., F.R.S.E.

DISEASES OF SHEEP AND CATTLE

Sir John Ritchie, C.B., B.SC., D.V.SC., LL.D., F.R.C.V.S., D.V.S.M., F.R.S.E. (Chairman).
R. E. Glover, M.A., D.SC., F.R.C.V.S.
W. S. Gordon, C.B.E., PH.D., M.R.C.V.S., F.R.S.E.
L. E. Hughes, M.R.C.V.S., D.V.S.M., N.D.A.
Professor J. E. Nichols, M.SC., PH.D., F.R.S.E.
Professor Alex Robertson, M.A., B.SC., PH.D., M.R.C.V.S., F.R.I.C., F.R.S.E.
A. W. Stableforth, C.B., D.SC., M.R.C.V.S., D.V.S.M.
J. T. Stamp, D.SC., M.R.C.V.S., F.R.S.E.
Professor W. L. Weipers, B.SC., F.R.C.V.S., D.V.S.M., F.R.S.E.
J. M. Payne, B.SC., PH.D., M.R.C.V.S. (Technical Secretary).

PLANTS AND SOILS

ENVIRONMENT IN GLASSHOUSES

Professor J. W. Munro, C.B.E., M.A., D.SC. (Chairman).
Professor G. E. Blackman, M.A., F.R.S.
W. H. Cashmore, C.B.E., B.A., N.D.A.
E. Danter, M.A., A.INST.P.
R. Gardner, N.D.H.
Professor O. V. S. Heath, D.SC., F.R.S.
Professor J. P. Hudson, M.B.E., G.M., M.SC., PH.D., N.D.H.
W. J. C. Lawrence, O.B.E., V.M.H.
E. R. Leonard, D.SC., A.R.C.S.
L. G. Morris, B.SC.(ENG.), A.F.R.A.E.S.
G. F. Sheard, M.SC.
L. P. Smith, B.A.
L. Stenning.
Principal M. A. H. Tincker, M.A., D.SC., F.L.S.
R. G. Voysey, A.C.G.I., A.M.I.MECH.E.
Professor C. P. Whittingham, B.A., D.SC., PH.D., F.R.I.C.

FIELD WATER CONTROL

A. B. Stewart, C.B.E., M.A., B.SC., PH.D., F.R.I.C., F.R.S.E. (Chairman).
Professor T. A. Bennet-Clark, M.A., PH.D., F.R.S.
W. H. Cashmore, C.B.E., B.A., N.D.A.
E. C. Childs, SC.D., PH.D.
J. Crooks.
R. Glentworth, B.S.A., PH.D.
Sir Claude Inglis, C.I.E., M.A.I., M.I.C.E., F.R.S.
E. A. G. Johnson, C.B.E., B.SC., M.I.C.E., M.I.W.E.
W. O. Kinghorn, B.SC.
H. H. Nicholson, M.B.E., M.A.
J. D. Ovington, B.SC., PH.D.
H. L. Penman, O.B.E., M.SC., PH.D., F.INST.P., F.R.S.
F. J. Richards, D.SC., F.R.S.
R. H. Smith, B.A.
D. J. Watson, M.A., PH.D.
Rice Williams, O.B.E., D.SC.

HOP RESEARCH

Professor T. Wallace, C.B.E., M.C., D.SC., F.R.I.C., V.M.H., F.R.S. (Chairman).
G. D. H. Bell, B.SC., PH.D.
A. H. Cook, D.SC., F.R.I.C., F.R.S.
A. Cronk.
H. S. Darling, B.SC., PH.D., M.AGR., A.I.C.T.A.
H. J. Hamblin, O.B.E., B.A.
R. V. Harris, D.SC., A.R.C.S., D.I.C.
W. G. Keyworth, PH.D., A.R.C.S., D.I.C.
W. C. Moore, C.B.E., M.A.
Sir Thomas Neame, V.M.H.
J. Nott, M.B.E.
N. B. Smiley.
Professor R. L. Wain, D.SC., PH.D., F.R.I.C., F.R.S.

POTATO PROBLEMS

Sir William G. Ogg, M.A., B.SC., PH.D., LL.D., F.R.S.E. (Chairman).
G. D. H. Bell, B.SC., PH.D.
W. Black, D.SC., PH.D., F.R.S.E.
W. G. Burton, M.A., B.SC.
K. S. Dodds, D.SC., PH.D.
J. L. Hardie, B.SC., PH.D.
J. M. Hirst, D.SC., PH.D.
F. R. Horne, C.B.E., M.A., N.D.A., N.D.D.
E. C. Large, B.SC., F.R.I.C.
Sir David Lowe, C.B.E., F.R.S.E.
J. Marshall.
Professor F. L. Milthorpe, M.SC., PH.D., D.I.C.
Professor Alexander Robertson, M.A., B.SC., PH.D., LL.D., F.R.S.
F. E. Shotton, M.A., DIP.AGRIC.
A. R. Wilson, B.SC., M.S., PH.D.

SPRAY DRIFT

Professor H. G. H. Kearns, O.B.E., B.SC., PH.D., DIP.AGRIC. (Chairman).
W. H. Cashmore, C.B.E., B.A., N.D.A.
R. F. Hill.
W. C. Moore, C.B.E., M.A.
James Philp, B.SC., PH.D.
B. D. A. Tucker.
Professor R. L. Wain, D.SC., PH.D., F.R.I.C., F.R.S.
E. K. Woodford, O.B.E., M.SC., PH.D., D.I.C.

GROUPS

ANIMALS

CARCASE QUALITY STUDIES

R. Scarisbrick, M.A., PH.D., M.R.C.V.S., A.R.I.C. (Chairman).
A. J. Brookes, M.A.
D. P. Gatherum.
F. R. Gerrard, M.B.E.
Sir John Hammond, C.B.E., M.A., D.SC., F.R.S.
G. Harrington, M.A.
K. Bryce Jones, B.SC., PH.D., F.R.I.C., A.R.C.S.
J. W. B. King, M.A., PH.D.
G. E. Lamming, B.SC., M.S., PH.D.
R. A. Lawrie, PH.D., A.R.I.C.
P. J. Macfarlan, B.SC., N.D.A., N.D.D.
I. L. Mason, B.A.
R. W. Pomeroy, M.A., PH.D.
T. R. Preston, B.SC., PH.D.
J. C. Tayler, M.A., DIP.AGRIC.

COLLABORATIVE TESTS OF PROTEIN QUALITY IN ANIMAL FEEDING STUFFS

S. K. Kon, D.SC., PH.D., F.R.I.C. (Chairman).
*A. E. Bender, B.SC., PH.D., F.R.I.C.
*A. A. Bindloss, B.SC., DIP.AGRIC.
*A. W. Boyne, B.SC.
R. Braude, D.SC., PH.D.
*K. J. Carpenter, M.A., B.SC., PH.D.
Marie E. Coates, PH.D., F.P.S.
*W. F. J. Cuthbertson, B.SC., PH.D., F.R.I.C.
*J. E. Ford, B.SC.(AGRIC.), PH.D.
Kathleen M. Henry, D.SC., PH.D., A.R.C.SC.I., F.R.I.C.
A. E. Humphreys.
G. S. Johnson.
D. B. Lisle, B.SC., PH.D., A.R.I.C.
D. S. Miller, B.SC.
†F. H. Moult, M.SC.
W. R. Muir, B.SC.
June Olley, PH.D.
S. A. Price, B.SC., F.R.I.C.
G. D. Rosen, B.SC., PH.D., F.R.I.C.
J. A. Stott.
G. Walley, B.SC., F.R.I.C.
A. L. Walther, M.A., M.R.C.V.S.
D. Waterworth.
J. Williams, B.SC., PH.D., F.R.I.C.
*A. A. Woodham, B.SC., PH.D., F.R.I.C. (Member and Technical Secretary).

* Also member of the Group's Steering Committee
† Chairman of the Group's Steering Committee

OESTROGENS

(Appointed in consultation with the M.R.C.)

Professor Sir Solly Zuckerman, C.B., M.A., M.D., D.SC., F.R.S. (Chairman).
P. M. F. Bishop, D.M.
W. E. Bowden.
Professor Sir Charles Dodds, M.V.O., D.SC., PH.D., M.D., F.R.C.P., F.R.I.C., F.R.S.
S. J. Folley, D.SC., PH.D., F.R.S.
R. F. Glascock, B.SC., PH.D.
G. E. Lamming, B.SC., M.S., PH.D.
Professor A. S. Parkes, C.B.E., M.A., SC.D., F.R.S.
T. R. Preston, B.SC., PH.D.

PLANTS AND SOILS

COMPARISON OF METHODS OF ANALYSIS OF MINERAL ELEMENTS IN PLANTS

J. B. E. Patterson, M.SC., F.R.I.C. (Chairman).
M. Allen, B.SC.
C. Bould, M.SC., PH.D.
W. M. Crooke, B.SC., PH.D., A.R.I.C.
E. J. Hewitt, B.SC., PH.D., A.K.C.
E. C. Humphries, D.SC.
R. L. Mitchell, B.SC., PH.D., F.R.I.C., F.R.S.E.
D. J. D. Nicholas, D.SC., PH.D., A.K.C., F.R.I.C.
F. H. Vanstone, B.SC., PH.D., A.INST.P.
R. G. Warren, B.SC.

A.R.C. SCHOLARSHIPS COMMITTEE

E. G. Cox, T.D., D.SC., F.INST.P., F.R.I.C., F.R.S. (Chairman of Main Committee).

BOTANY GROUP

Professor T. A. Bennet-Clark, M.A., PH.D., F.R.S. (Chairman).
Professor K. Mather, C.B.E., D.SC., PH.D., F.R.S.
A. F. Posnette, SC.D., A.I.C.T.A.
Professor W. T. Williams, D.SC., PH.D., A.R.C.S., D.I.C., F.L.S.

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N. W. Pirie, M.A., F.R.S.
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W. H. Cashmore, C.B.E., B.A., N.D.A.
Professor E. M'Ewen, M.SC., M.I.MECH.E.
Professor W. A. Tuplin, D.SC., M.I.MECH.E.

ENTOMOLOGY GROUP

Professor V. B. Wigglesworth, C.B.E., M.A., M.D., B.CHIR., F.R.S. (Chairman).
K. Mellanby, C.B.E., B.A., SC.D., PH.D.
I. Thomas, M.SC., PH.D.
D. W. Wright, M.A.

STATISTICS GROUP

D. J. Finney, M.A., SC.D., F.R.S., F.R.S.E.
F. Yates, C.B.E., SC.D., F.R.S.

ZOOLOGY GROUP

Professor D. R. Newth, PH.D. (Chairman).
J. B. Brooksby, D.SC., PH.D., M.R.C.V.S.
Professor I. Chester Jones, D.SC., PH.D.
H. P. Donald, D.SC., PH.D., F.R.S.E.
Professor C. L. Oakley, M.D., B.S., D.SC., F.R.S.
A. W. Stableforth, C.B., D.SC., M.R.C.V.S., D.V.S.M.

INTERDEPARTMENTAL AND JOINT COMMITTEES

JOINT A.R.C./M.R.C./D.C. COMMITTEE ON BIOLOGICAL PROBLEMS (NON-MEDICAL) OF NUCLEAR PHYSICS

Sir James Denby Roberts, BART., O.B.E., J.P. (Chairman).
W. G. Alexander, C.B.E., M.A.
H. R. Barnell, M.A., B.SC., PH.D.
Professor G. E. Briggs, M.A., F.R.S.
R. F. Glascock, B.SC., PH.D.
Professor J. E. Harris, C.B.E., M.A., PH.D., F.R.S.
A. W. Kenny, M.A., B.SC., F.R.I.C.
J. F. Loutit, C.B.E., D.M., F.R.C.P., F.R.S.
A. S. McLean, M.B., CH.B., D.I.H., C.P.H.
W. G. Marley, O.B.E., M.SC., PH.D.
R. Scott Russell, M.A., M.SC., PH.D.
Sir Harold Sanders, M.A., PH.D.
A. W. Stableforth, C.B., D.SC., M.R.C.V.S., D.V.S.M.
E. B. Worthington, M.A., PH.D.

MANAGING SUB-COMMITTEE ON MONITORING

J. F. Loutit, C.B.E., D.M., F.R.C.P., F.R.S. (Chairman).
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K. L. Blaxter, D.SC., PH.D., N.D.A.
F. J. Bryant, B.SC., PH.D., D.I.C., A.R.C.S.
D. J. Finney, M.A., SC.D., F.R.S., F.R.S.E.
Miss D. F. Hollingsworth, O.B.E., B.SC., F.R.I.C.
J. L. McGirr, B.SC., M.R.C.V.S.
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Professor W. V. Mayneord, C.B.E., D.SC., F.INST.P.
E. R. Mercer, B.SC.
R. Scott Russell, M.A., M.SC., PH.D.
C. L. Smith, M.A., PH.D.

APPENDIX II

SUMMARY OF THE EXPENDITURE OF THE COUNCIL DURING THE YEAR ENDED 31st MARCH, 1962

	Current	*Capital*	*Receipts*	*Net Total*
	£	£	£	£
Headquarters : administration	206,513	—	8,221	198,292
Institute for Research in Animal Diseases	355,610	46,455	147,517	254,548
Animal Breeding Research Organisation	260,616	16,090	123,545	153,161
Institute of Animal Physiology	290,198	50,204	18,745	321,657
Poultry Research Centre	86,508	1,186	2,886	84,808
Unit of Insect Physiology	31,241	—	—	31,241
Virus Research Unit	41,757	—	132	41,625
Unit of Reproductive Physiology and Biochemistry	57,360	5,505	2,386	60,479
Unit of Experimental Agronomy	25,668	—	8,703	16,965
Unit of Animal Genetics	64,028	—	—	64,028
Unit of Systemic Fungicides	17,629	—	—	17,629
Unit of Statistics	14,268	—	—	14,268
Radiobiological Laboratory	78,245	119,502	5,552	192,195
Unit of Plant Physiology	19,282	—	—	19,282
Unit of Plant Morphogenesis and Nutrition	11,860	2,482	—	14,342
Weed Research Organisation	51,342	61,807	6,091	107,058
Farm Buildings Unit	13,060	—	184	12,876
Other Units	31,487	—	—	31,487
Ditton Laboratory	88,157	726	5,455	83,428
Low Temperature Research Station	185,700	5,500	30,360	160,840
Pest Infestation Laboratory	162,130	4,161	14,563	151,728
External Scientific Staff	26,514	—	30	26,484
Special Research Grants to Universities, etc.	148,960	—	—	148,960
Grants to University Departments for Special Equipment	13,479	—	—	13,479
Training Awards and Fellowships	27,558	—	—	27,558
Grants for Experimental Farm Buildings	23,597	—	—	23,597
Grant to Research Institutes :—				
Long Ashton Research Station	245,860	25,186	—	271,046
East Malling Research Station	309,383	15,742	—	325,125
Foot-and-Mouth Disease Research Institute	313,168	43,597	3	356,762
Glasshouse Crops Research Institute	132,495	39,653	—	172,148
Grassland Research Institute	202,044	1,979	—	204,023
Houghton Poultry Research Station	75,043	94,263	10,080	159,226
John Innes Institute	148,565	2,398	—	150,963
Hop Research Centre, Wye College	31,164	—	14,537	16,627
National Institute of Agricultural Engineering	427,116	11,283	—	438,399
National Vegetable Research Station	136,350	12,929	—	149,279
Plant Breeding Institute, Cambridge	99,148	4,512	—	103,660
National Institute for Research in Dairying	458,007	98,108	—	556,115
Rothamsted Experimental Station	583,046	86,197	—	669,243
Welsh Plant Breeding Station	177,072	34,075	—	211,147
Hannah Dairy Research Institute	—	1,502	—	1,502
TOTAL	5,671,228	785,042	398,990	6,057,280

Grants made by the Department of Agriculture and Fisheries for Scotland to Research Institutes in Scotland during the year ended 31st March, 1962

	Current	*Capital*	*Total*
	£	£	£
Animal Diseases Research Association	118,923	33,423	152,346
Rowett Research Institute	288,490	11,896	300,386
Hannah Dairy Research Institute	121,012	2,571	123,583
Scottish Society for Research in Plant Breeding	61,140	2,701	63,841
Macaulay Institute for Soil Research	209,550	149,009	358,559
National Institute of Agricultural Engineering (Scottish Station)	51,540	88,752	140.292
Scottish Horticultural Research Institute	109,170	8,681	117,851
Hill Farming Research Organisation	75,359	3,895	79,254
TOTAL	1,035,184	300,928	1,336,112

APPENDIX III

STATE-AIDED AGRICULTURAL RESEARCH INSTITUTES

England and Wales	*Tel. No.*
Agricultural and Horticultural Research Station, Long Ashton, Bristol. *Director:* Professor H. G. H. Kearns, O.B.E., B.SC., PH.D., DIP.AGRIC.	Long Ashton 2181
East Malling Research Station, Maidstone, Kent. *Director:* F. R. Tubbs, C.B.E., M.SC., PH.D., A.R.C.S., D.I.C., F.L.S.	West Malling 3033
Foot-and-Mouth Disease Research Institute, Research Institute (Animal Virus Diseases), Pirbright, Surrey. *Director:* Ian A. Galloway, D.SC., M.R.C.V.S.	Worplesden 2441
Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex. *Director:* F. W. Toovey, O.B.E., B.SC., A.R.C.S., A.I.C.T.A.	Littlehampton 1414
Grassland Research Institute, Hurley, Maidenhead, Berks. *Director:* William Davies, D.SC.	Hurley 363/4
Houghton Poultry Research Station, Houghton, Huntingdon. *Director:* R. F. Gordon, D.SC., M.R.C.V.S.	St. Ives (Hunts) 3168-9 and 3388
John Innes Institute, Bayfordbury, Hertford, Herts. *Director:* K. S. Dodds, D.SC., PH.D.	Hertford 3191
National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds. *Director:* W. H. Cashmore, C.B.E., B.A., N.D.A.	Silsoe 421
National Institute for Research in Dairying, Shinfield, Reading, Berks. *Director:* Professor R. G. Baskett, O.B.E., M.SC., F.R.I.C.	Reading 83103
National Vegetable Research Station, Wellesbourne, Warwick. *Director:* James Philp, B.SC., PH.D.	Wellesbourne 382/4

	Tel. No.
Plant Breeding Institute, Maris Lane, Trumpington, Cambridge. *Director:* G. D. H. Bell, B.SC., PH.D.	Trumpington 3234
Rothamsted Experimental Station, Harpenden, Herts. *Director:* F. C. Bawden, M.A., F.R.S.	Harpenden 4671
Welsh Plant Breeding Station, Plas Gogerddan, Aberystwyth, Cardiganshire. *Director:* Professor P. T. Thomas, B.SC., PH.D.	Bow Street 255/57
Wye College Hop Research Centre, Ashford, Kent.	Wye 401

Scotland

Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh, 9. *Director:* J. T. Stamp, D.SC., M.R.C.V.S., F.R.S.E.	Liberton 3262
Hannah Dairy Research Institute, Kirkhill, Ayr. *Director:* J. A. B. Smith, C.B.E., D.SC., PH.D., F.R.S.E.	Prestwick 77292/3
Hill Farming Research Organisation, 48, Palmerston Place, Edinburgh, 12. *Director:* A. R. Wannop, O.B.E., B.SC.(AGR.), B.ENG., F.R.S.E.	Caledonian 3231/2
Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen. *Director:* A. B. Stewart, C.B.E., M.A., B.SC., PH.D., F.R.I.C., F.R.S.E.	Aberdeen 38611
National Institute of Agricultural Engineering, Scottish Station, Bush and Dryden Estates, Milton Bridge, Penicuik, Midlothian. *Director:* W. J. West, B.A., DIP.AGRIC.	Fairmilehead 2147/8
Rowett Research Institute, Bucksburn, Aberdeen. *Director:* D. P. Cuthbertson, C.B.E., M.D., D.SC., LL.D., F.R.S.E.	Bucksburn 8
Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee. *Director:* T. Swarbrick, M.SC., PH.D.	Invergowrie 441

	Tel. No.
Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian. *Director:* J. W. Gregor, C.B.E., D.SC., PH.D., F.L.S., F.R.S.E.	Fairmilehead 2172/1

AGRICULTURAL RESEARCH COUNCIL INSTITUTES AND UNITS

	Tel. No.
Institute for Research on Animal Diseases, Compton, Newbury, Berks. *Director:* W. S. Gordon, C.B.E., PH.D., M.R.C.V.S., F.R.S.E.	Compton 343
Animal Breeding Research Organisation, H.Q.: 6, South Oswald Road, Edinburgh, 9. *Director:* H. P. Donald, D.SC., PH.D., F.R.S.E.	Newington 3725/6
Institute of Animal Physiology, Babraham, Cambridge. *Director:* J. H. Gaddum, M.A., SC.D., M.R.C.S., L.R.C.P., F.R.S., F.R.S.E.	Sawston 2312
Poultry Research Centre, King's Building, West Mains Road, Edinburgh, 9. *Director:* T. C. Carter, O.B.E., D.SC., F.R.S.E.	Newington 4461
Ditton Laboratory, Larkfield, Maidstone, Kent. *Director:* R. G. Tomkins, M.A., PH.D., M.INST.R.	West Malling 3441
Low Temperature Research Station, Downing Street, Cambridge. *Director:* E. C. Bate-Smith, C.B.E., SC.D., PH.D.	Cambridge 50477
Pest Infestation Laboratory, London Road, Slough, Bucks. *Director:* G. V. B. Herford, C.B.E., M.SC.	Slough 21295
Radiobiological Laboratory, Letcombe Regis, Wantage, Berks. *Director:* R. Scott Russell, M.A., M.SC., PH.D.	Wantage 327
Weed Research Organisation, Begbroke Hill, Kidlington, Oxford. *Director:* E. K. Woodford, O.B.E., M.SC., PH.D., D.I.C.	Kidlington 3461

	Tel. No.
Unit of Animal Genetics, Institute of Animal Genetics, Edinburgh University, King's Buildings, West Mains Road, Edinburgh, 9. *Honorary Director:* Professor C. H. Waddington, C.B.E., M.A., SC.D., F.R.S.	Newington 1081
Unit of Biometrical Genetics, Department of Genetics, University of Birmingham, Edgbaston, Birmingham, 15. *Honorary Director:* Professor K. Mather, C.B.E., D.SC., PH.D., F.R.S.	Edgbaston 1552
Unit of Embryology, University College of North Wales, Bangor, Caerns. *Honorary Director:* Professor F. W. Rogers Brambell, B.A., D.SC., PH.D., F.R.S.	Bangor 3225
Unit of Experimental Agronomy, Department of Agriculture, University of Oxford. *Honorary Director:* Professor G. E. Blackman, M.A., F.R.S.	Oxford 57245
Unit of Flower Crop Physiology, Horticultural Research Laboratories, Shinfield Grange, Shinfield, Reading, Berks. *Honorary Director:* Professor O. V. S. Heath, D.SC., F.R.S.	Reading 83226
Unit of Insect Physiology, Department of Zoology, University of Cambridge, Downing Street, Cambridge. *Director:* Professor V. B. Wigglesworth, C.B.E., M.A., M.D., B.CHIR., F.R.S.	Cambridge 58717
Unit of Microbiology, Department of Microbiology, Sheffield University. *Honorary Director:* Professor S. R. Elsden, B.A., PH.D.	Sheffield 78555
Unit of Plant Morphogenesis and Nutrition, Wye College, Ashford, Kent. *Director:* F. J. Richards, D.SC., F.R.S.	Wye 401
Unit of Plant Physiology, Imperial College of Science and Technology, Beit Building, Prince Consort Road, London, S.W.7. *Director:* Professor Helen K. Porter, D.SC., F.R.S.	Kensington 5111
Unit of Reproductive Physiology and Biochemistry, 307, Huntingdon Road, Cambridge. *Director:* T. R. R. Mann, C.B.E., M.D., SC.D., PH.D., F.R.S.	Cambridge 76278

	Tel. No.
Unit of Soil Physics, School of Agriculture, University of Cambridge, Cambridge. *Honorary Director:* E. C. Childs, SC.D., PH.D.	Cambridge 58381
Unit of Statistics, University of Aberdeen, Meston Walk, Old Aberdeen. *Director:* D. J. Finney, M.A., SC.D., F.R.S., F.R.S.E.	Aberdeen 45251
Statistics Group, School of Agriculture, University of Cambridge. *Under Supervision of:* R. C. Campbell, M.A., PH.D.	Cambridge 58381
Systemic Fungicide Unit, Wye College, Ashford, Kent. *Honorary Director:* Professor R. L. Wain, D.SC., PH.D., F.R.I.C., F.R.S.	Wye 401
Virus Research Unit, Huntingdon Road, Cambridge. *Director:* R. Markham, M.A., PH.D., F.R.S.	Cambridge 76146 and 76620

APPENDIX IV

RESEARCH STUDENTSHIPS AND FELLOWSHIPS

(*a*) RESEARCH STUDENTSHIPS

These studentships are intended to enable young graduates who wish to make a career in agricultural research either to take a further course of study or to undertake a specific research project under supervision as a means of training in research methods, or to read for a veterinary degree in order to equip themselves for research in fields in which this added qualification is likely to be of particular advantage. They are open to honours graduates in science or those holding a veterinary qualification and to honours graduates in agriculture or horticulture who have shown special interest in one of the basic sciences.

The following twenty-six awards were made in 1961:—

Name	*Place of Tenure*	*Subject*
Miss J. A. Bailey ..	Cambridge University ..	Statistics
Miss M. A. H. Baillie..	Glasgow University	Bacteriology
J. R. Baker	Bristol University	Animal Physiology
D. Boothby	Wye College	Botany (selective toxicity)
D. H. Brooks	Cambridge University ..	Plant Pathology
P. H. W. Butterworth..	Liverpool University ..	Biochemistry.
G. C. Coles	Cambridge University ..	Insect Biochemistry
H. A. Collin	Imperial College	Plant Physiology
J. W. Croft	Birmingham University ..	Plant Genetics
R. N. Crossett.. ..	Oxford University	Plant Physiology
A. L. R. Findlay ..	Cambridge University ..	Veterinary Training Grant
B. A. Gale	Cambridge University ..	Insect Physiology
R. N. Hardy	Cambridge University ..	Animal Physiology
I. N. Healey	University College, Swansea	Insect Ecology
R. J. Hillyer	Imperial College	Entomology
Miss S. Horrocks ..	Liverpool University ..	Veterinary Pathology
M. J. Kearsey	Birmingham University ..	Genetics
Miss B. Kirtley ..	Glasgow University	Bacteriology
Miss A. M. Lever ..	Oxford University	Plant Biochemistry
M. J. Makin	Aberdeen University.. ..	Soil Science
Miss A. C. Paterson ..	Sheffield University	Microbiology
M. Richardson ..	Hull University	Plant Biochemistry
R. E. Spier	Oxford University	Biochemistry
R. K. Stewart	Glasgow University	Entomology
A. Thomas	Liverpool University ..	Soil Microbiology
G. C. Webster	London University	Animal Physiology

At 31st March, 1962, the number of students in training was 60, divided amongst the different disciplines as follows:—

Botany	*Chemistry*	*Entomology*	*Statistics*	*Zoology and Veterinary Science*
22	16	9	1	12

(*b*) FELLOWSHIPS

Up to three Agricultural Research Fellowships, tenable for a maximum period of three years, are available annually. The fellowships awarded during the year under review were:—

Name	*Place of Tenure*	*Subject*
D. J. Bartlett, M.A., M.B., B.CHIR., PH.D.	Institute of Animal Physiology, Babraham, Cambridge.	Research on the separation of male and female determining spermatozoa.
R. J. Ellis, B.SC., PH.D...	Oxford University	Plant Biochemistry: research on the metabolic pathway by which higher plants reduce sulphate groups to sulphydryl.

Veterinary Research Fellowships, tenable for three years, are available to veterinary graduates with not less than three years' post-graduate experience who wish to continue their research for a further period before seeking a post. No awards were made during the year under review.

APPENDIX V

SPECIAL RESEARCH GRANTS

During the period covered by this report the Council has continued to make grants to universities, colleges and other organisations to assist in research projects on subjects of interest to the Council. Grants are normally limited to three years but occasionally they are made for longer periods.

The following is a list of projects supported by the Council as at 31st March, 1962:—

1. Aberdeen University

Department of Soil Science
Research on the composition and properties of soil organic matter.

2. Aberystwyth, University College of Wales

(i) *Department of Agriculture*
The establishment and subsequent development of species sown by a sod seeder.

(ii) *Department of Agricultural Biochemistry*
(*a*) The biosynthesis of thiamine in micro-organisms.
(*b*) The susceptibility of certain strains of barley to D.D.T.
(*c*) Some aspects of the biochemistry of plant sulpholipid.

(iii) *Department of Animal Husbandry*
The feed intake and requirements of sheep at different stages of production, and at grazing.

(iv) *Department of Zoology*
Insect cell culture.

3. Bangor, University College of North Wales

(i) *Department of Agricultural Botany*
The mineral nutrition of contrasting natural populations of agriculturally important grass species.

(ii) *Department of Agricultural Chemistry*
Inorganic analysis by paper chromatography and similar methods.

(iii) *Department of Biochemistry and Soil Science*
(*a*) Physiological investigations on cattle bracken poisoning.
(*b*) The influence of nutritional factors upon peptidase activity.
(*c*) The metabolism of hill sheep in their natural environment.

(iv) *Department of Zoology*
Serological investigations.

4. Birmingham University

Department of Physiology
The role of relaxin in reproduction and other physiological processes in animals.

5. Bristol University

(i) *Department of Pharmacology*
Determination of oxytocin in blood.

(ii) *Department of Physiology*
Ketosis of cattle and sheep.

6. Cambridge University

(i) *School of Agriculture*

(*a*) Mycological aspects of cellulose decomposition in soils.
(*b*) Protein quality in human foods and animal feeding stuffs.
(*c*) Studies of poultry genetics employing inbred lines.
(*d*) Variability in a Lowland sheep flock.

(ii) *Department of Animal Pathology*

(*a*) Research on respiratory diseases in poultry.
(*b*) Research on virus diseases of pigs.
(*c*) Immunity to helminth infection with special reference to functional antigens.

(iii) *Department of Biochemistry*

(*a*) The biochemistry of chloroplasts in relation to photosynthetic phosphorylation.
(*b*) Biochemical synthesis of the constituents of the plant cell wall.
(*c*) The biochemistry of the uterus.

(iv) *Department of Veterinary Clinical Studies*

(*a*) The physiological basis of neonatal mortality among animals.
(*b*) Blood groups of the pig.
(*c*) The biochemistry of blood copper and iron in the bovine.
(*d*) Research on respiratory diseases of pigs.

7. Durham University (King's College, Newcastle-upon-Tyne)

(i) *School of Agriculture*

(*a*) Soil structure studies on restored opencast coal sites.
(*b*) The biology and ecology of frit fly in Northumberland.
(*c*) The progeny testing of cattle for meat and milk production.
(*d*) Studies of pig farrowing accommodation.

(ii) *Department of Civil Engineering*

Investigation of the pressures exerted on the walls of concrete stave silos.

(iii) *Department of Zoology*

Research in the field of plant nematology.

8. Edinburgh University

(i) *School of Agriculture*

(*a*) Research on egg weight in the domestic fowl : the genetic determination of initial egg weight and its increase to mature weight.
(*b*) Studies on strains of *Rhizobium* associated with wild white clover in hill soils.

(ii) *Department of Biochemistry*

The metabolism of iron in immature pullets and laying hens.

(iii) *Department of Biophysics*

The salt and water relations of plant cells and tissues.

(iv) *Royal (Dick) School of Veterinary Studies Department of Veterinary Hygiene and Preventive Medicine*

(*a*) Factors affecting the absorption of calcium and magnesium from the alimentary tract of the ruminant.
(*b*) Study of citrate metabolism in ruminants.
(*c*) Research on the influence of incubation temperature on chick embryo orientation.

(v) *Department of Veterinary Pharmacology*
Investigation into the mode of action of drugs used in the treatment of fascioliasis with a view to improving therapy.

(vi) *Department of Veterinary Surgery*
Extension of blood and plasma transfusion service for canine species to other domestic mammals.

9. Glasgow University

(i) *Department of Bacteriology*
Research on aerobic spore-forming bacteria pathogenic for Lepidoptera.

(ii) *Veterinary Hospital*
(*a*) A study of bovine brucellosis in the field.
(*b*) Bacteriological research.
(*c*) The urinary changes associated with electrolyte changes in body fluids.
(*d*) Study of the incidence of embryonic death in cattle and associated physiological and pathological factors.
(*e*) Research on leptospirosis in pigs.

(iii) *Department of Zoology*
The parental control of larval diapause in *Lucilia caesar* (Diptera Cyclorrhapha) and related species.

10. Grassland Research Institute
Studies of certain aspects of the physiology of wild white clover.

11. Harper Adams Agricultural College
(*a*) Pig husbandry investigations.
(*b*) Poultry husbandry investigations.

12. Houghton Poultry Research Station
Avian physiology.

13. Leeds University

(i) *Department of Agriculture*
(*a*) The nutrition of the pregnant sow.
(*b*) Investigation of the lean mass in pigs by gamma-ray analysis.
(*c*) Research on clover rot.

(ii) *Department of Biomolecular Structure*
(*a*) A study of wool follicle activity by means of skin grafting.
(*b*) Interpretation of fibre types in sheep.

(iii) *Department of Textile Industries*
The constitution of insect and plant waxes.

14. Liverpool University

(i) *Department of Biochemistry*
The metabolism of Vitamin A acid in animal tissues.

(ii) *School of Tropical Medicine*
(*a*) Research on the host responses of turkeys and chickens to protozoa.
(*b*) Liver function in the turkey and fowl and its derangement in histomoniasis.

(iii) *Department of Veterinary Pathology*
Research on the pathogenesis of fowl typhoid.

(iv) *Department of Veterinary Preventive Medicine*

(*a*) Research on respiratory diseases in poultry.

(*b*) Quantitative assessment of digestive and synthetic processes in the alimentary tract of ruminants.

(*c*) Serological studies of lungworm infection in farm animals.

(*d*) The housing and maintenance of the Reaseheath P line of Rhode Island inbred stock.

(v) *Department of Zoology*

Research on taste in birds.

15. London University

School of Hygiene and Tropical Medicine

Study of the wild hosts of louping ill and Dalcairnie-5 viruses.

Imperial College of Science and Technology

(i) *Department of Chemistry*

(*a*) The fixation of molecular nitrogen by micro-organisms.

(*b*) The reactions, synthesis and properties of soil minerals (five-year block grant).

(ii) *Department of Zoology and Applied Entomology*

(*a*) Research on insect ecology (a five-year block grant).

(*b*) Research on the fumigation of seed-borne fungi.

(*c*) Research on chemical control of narcissus bulb eelworm.

King's College

(i) *Department of Botany*

Nucleic acid metabolism and CO_2 fixation in relation to endogenous rhythms and photoperiodism.

(ii) *Department of Zoology*

Research on amoeboid movement.

Queen Elizabeth College

Research on phytate and other magnesium-binding substances as a possible cause of hypomagnesaemia in ruminants.

Royal Veterinary College

(i) *Department of Animal Husbandry and Veterinary Hygiene*

Studies of broiler production under closely controlled experimental conditions.

(ii) *Field Station*

Study of bone reaction and fracture repair in the pig.

(iii) *Department of Pathology*

Research on the development in the tick of the causal agent of redwater fever of cattle.

St. Bartholomew's Medical College

Cytological study of the nature and causes of the infertility that occurs when *Drosophila subobscura* is inbred by continued brother-sister mating.

University College

(i) *Department of Botany*

Research on the physiological role and metabolism of certain secondary nitrogenous substances in higher plants and micro-organisms.

(ii) *Department of Chemistry*

Research on threonine dehydrase from sheep liver.

University College Hospital Medical School
Research on biliary secretions in the rabbit.

Wye College
(*a*) Research on pig breeding.
(*b*) Poultry research.

16. Manchester University
Department of Botany
(*a*) Research on Lysosomes in plants.
(*b*) Morphogenetic investigations on plant material.

17. National Vegetable Research Station
The effect of sub-lethal doses of herbicides on vegetable crops.

18. Nottingham University
School of Agriculture
(*a*) The methods of controlling the responses of plants to environmental conditions.
(*b*) The effects on growth of divergence of actual from potential transpiration rates.
(*c*) The growth and development of the potato plant in relation to crop production techniques.
(*d*) The physiology of sprouting of potato tubers.
(*e*) Studies in poultry nutrition.

19. Oxford University
(i) *Department of Agriculture*
(*a*) The pattern of uptake of growth regulators by higher plants.
(*b*) The physiological actions of growth regulators.
(*c*) Research on the Take-All disease of cereals and grasses.
(*d*) The uptake of growth regulators by wheat and oats.
(ii) *Department of Entomology*
A taxonomic and biological study of the parasites of the jumping plant lice (Fam. Psyllidae).

20. Reading University
(i) *Department of Agriculture*
(*a*) The effect of irrigation on the production of milk from grasslands.
(*b*) Poultry husbandry investigations.
(ii) *Department of Agricultural Botany*
(*a*) Water relations of vegetation on chalk grassland.
(*b*) Research on physiological adaptations in ecotypes of *Trifolium repens* and *Festuca ovina*.
(*c*) A physiological examination of the effects of potassium and sodium on red beet and barley.
(iii) *Department of Horticulture*
Research on the physiology of stomata.
(iv) *Department of Physiological Chemistry*
Research into the calcium and phosphorus requirements of laying hens.

21. Rothamsted Experimental Station
(*a*) Maintenance of the electronic computer in the Statistical Department.
(*b*) Research on the chemical investigation of the scent factor in the " queen substance " effect in honey bees and cognate subjects (in collaboration with the National Institute for Medical Research).

22. Rowett Research Institute

(*a*) The absorption and elimination of natural and radio-active isotopes of calcium, strontium and barium in sheep.

(*b*) Tests on proteins in feeding stuffs.

23. Sheffield University

(i) *Department of Bacteriology*
Research on toxoplasma infection in relation to ovine abortion.

(ii) *Department of Microbiology*
The metabolism of the rumen organism *Selenomonas ruminantium*.

(iii) *Department of Zoology*
Research on comparative endocrinology.

24. Southampton University

Department of Botany
Research into the mechanism by which Yellow Rust reduces yield in wheat.

25. Welsh Plant Breeding Station

The genetic and environmental control of flowering in cocksfoot.

26. Other Organisations

(i) *Animal Health Trust, Farm Livestock Research Centre*
Research on salmonellosis in calves.

(ii) *Electrical Research Association*
(*a*) Crop conservation and storage.
(*b*) Farm machinery and equipment.
(*c*) Electricity in livestock husbandry.
(*d*) Electricity in horticulture.
(*e*) Specialised applications of electricity.

(iii) *Ministry of Agriculture, Fisheries and Food : Plant Pathology Laboratory*
Research on the control of stem and bulb eelworm in Narcissus bulbs.

(iv) *The Lord Rothschild, G.M., Sc.D., F.R.S.*
The physiology and ultrastructure of spermatozoa.

APPENDIX VI

SPECIAL EQUIPMENT GRANTS

During the year under review the Council made the following grants for the purchase of special items of research equipment :—

1. Aberystwyth, University College of Wales
   Department of Agricultural Botany
   Integrating microdensitometer.

2. Glasgow University
   Departments of Veterinary Medicine and Veterinary Hospital Pathology
   Recorder and auxiliary equipment for cardiovascular studies.

3. London University, Wye College
   Department of Chemistry
   (*a*) Recording ultra-violet spectrophotometer.
   (*b*) Ultracentrifuge.

4. Oxford University
   Department of Agriculture
   High speed centrifuge.

APPENDIX VII

SCIENTIFIC STAFF ATTACHED TO UNIVERSITIES OR RESEARCH INSTITUTES

PLANT BIOCHEMISTRY

School of Biochemistry, Cambridge
R. Hill, M.A., SC.D., F.R.S.

Long Ashton Research Station
D. J. D. Nicholas, D.SC., PH.D., A.K.C., F.R.I.C.

REPRODUCTION

Molteno Institute of Biology and Parasitology, Cambridge
Mrs. C. L. Mann, M.D., PH.D.

LIPIDS OF LEAVES

Dunn Nutritional Laboratory, Cambridge
V. H. Booth, B.A., PH.D.

GRASS CONSERVATION

Department of Chemistry, University of Edinburgh
H. T. Macpherson, B.SC., PH.D.

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